INTERIM REPORT OF THE MISSOURI DIOXIN TASK FORCE

**submitted to
Governor Christopher S. Bond**

JUNE 1, 1983

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GOVERNOR CHRISTOPHER S. BOND

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Honorable Christopher S. Bond
Governor
State of Missouri
State Capitol
Jefferson City, MO 65101

Dear Governor Bond:

I hereby convey to you the interim report of the Dioxin Task Force as requested in your executive order 83-5.

Since its inception in February of this year, the task force has studied the volume of information on dioxin presented in papers and speeches by experts in the field. The recommendations in this report reflect that study.

The task force appreciates comments on this report as well as further guidance on the final report or any other matter you wish the task force to address.

Respectfully submitted,

James A. Finch

James A. Finch, Jr.
Chairman
Governor's Dioxin Task Force

JAF:brd

PREFACE

Explanation of Terms

This report deals with one extremely toxic member of a class of compounds commonly called "dioxins". Within the 75 possible chlorinated dioxins, there are 22 isomers of tetrachlorodibenzo-p-dioxin (TCDD). In Missouri, the contamination is almost exclusively with one highly toxic member of this family, the member "2,3,7,8-TCDD". For simplicity and unless otherwise stated, this report uses the terms "2,3,7,8-TCDD", "TCDD", and "dioxin" interchangeably, all referring to one member of a family of compounds.

EXECUTIVE ORDER
83-5

WHEREAS, extensive laboratory testing has confirmed the presence of dioxin at several locations in Missouri; and,

WHEREAS, dioxin is a potentially deadly chemical which threatens the health and safety of thousands of Missourians,

NOW, THEREFORE, I, CHRISTOPHER S. BOND, GOVERNOR OF THE STATE OF MISSOURI, by virtue of the authority vested in me by the Constitution and laws of Missouri, hereby establish the Governor's Task Force on Dioxin (hereinafter the "Task Force") which shall be composed of such residents of Missouri as from time to time may be appointed by the Governor. The Task Force shall include representatives of Missouri higher education institutions and Missouri companies which have expertise regarding hazardous wastes, as well as concerned citizens. The Chairman of the Task Force shall be designated by the Governor.

The purposes of the Task Force shall be as follows:

1. To examine and evaluate all known methods, processes and technologies for the destruction and containment of dioxin, particularly with respect to dioxin as it exists as a contaminant in soil and stream sediment at various locations in Missouri;

2. To examine and evaluate the public health dangers associated with dioxin, particularly with respect to dioxin as it exists as a contaminant in soil and stream sediment at various locations in Missouri;

3. To prepare and present, not later than June 1, 1983, an interim report which, inter alia, provides specific recommendations for solving those public health and environmental problems occurring in Times Beach, Missouri which are the result of dioxin contamination exacerbated by widespread flooding; and

4. To prepare and present, as soon as practicable but not later than October 1, 1983, a final report which includes the evaluations set forth in paragraphs 1 and 2 above, and which recommends a practical and effective plan of action for implementing comprehensive and permanent solutions to the public health and environmental problems caused by dioxin contamination in Missouri.

The Director of the Department of Natural Resources and the Director of the Division of Health shall make available such staff and support resources as are needed by the Task Force in the course of its deliberations. All meetings of the Task Force shall be open to the public, and a record shall be kept of all Task Force proceedings.

Members of the Task Force shall receive no compensation for their services, but shall be reimbursed from funds provided through the Department of Natural Resources for their reasonable and necessary expenses. The Task Force may contract for the services of such consultants and experts as it deems necessary and shall pay for such services from funds provided through the Department of Natural Resources or the Division of Health.

The Task Force shall meet at the call of the Chairman, or at the call of the Governor or his designate, and shall dissolve upon the issuance of its final report, unless extended by subsequent Executive Order.

IN TESTIMONY WHEREOF, I have hereunto set my hand and caused to be affixed the Great Seal of the State of Missouri, this 14th day of February, 1983.

Christopher S. Bond
GOVERNOR

ATTEST:

James C. Kirkpatrick
SECRETARY OF STATE

GOVERNOR'S DIOXIN TASK FORCE

The Honorable James A. Finch, Jr.
Judge
Chairman, Governor's Dioxin Task Force

Mr. Dwight Douglas
Douglas, Douglas & Johnson Law Offices

Mr. Ray Forrester
Engineering Manager & Dioxin Project Supt.
Syntex Agribusiness, Inc.

Dr. Perry King
Director, Quality Assurance Chemicals
Mallinkrodt, Inc.

Dr. Robert L. Powell
Assistant Professor of Chemical Engineering
Washington University

Dr. Carl J. Marienfeld
Professor of Family & Community Medicine
Environmental Health Surveillance Program
Sinclair Research Farm

Mrs. Sharon Rogers
Warren Countians Against Hazardous Waste

Dr. George Roush
Director, Dept. of Medicine & Environmental Health
Monsanto

Dr. James Shaddy
Associate Professor of Ecology
Northeast Missouri State University

Mrs. Betty Wilson
Environmental Quality Chairperson
League of Women Voters

TASK FORCE STAFF SUPPORT

Department of Natural Resources

Fred Lafser, Director
Ronald Kucera, Deputy Director

Robert Schreiber, Director - Division of Environmental Quality
Linda James, Assistant Director

David Bedan, Director - Waste Management Program
Joe Jansen, Environmental Engineer
Beth Rice, Environmental Engineer
Dan Tschirgi, Environmental Engineer
Dianne Luebbert, Clerk Steno
Martha Siegel, Clerk Typist

Mary Still, Director - Office of Public Affairs, Division of Management Services
Nancy Guyton, Office of Public Affairs

Department of Social Services

Dr. Robert Hotchkiss, M.D., Director - Division of Health

Dr. Denny Donnell, M.D., MPH, Director - Disease Prevention Section
Dr. Patrick Phillips, DVM, MSPH
Dr. Thomas Satalowich, DVM, MSPH
Jeff Staake, Dioxin Activities Coordinator

Governor's Remarks
Dioxin Task Force Meeting
February 23, 1983

Judge Finch, Members of the Task Force, Ladies and Gentlemen:

Let me extend first of all my warm welcome and my sincerest thanks to all of you who have agreed to serve on the task force. We've brought this distinguished group together to assist us in solving what has become to be Missouri's most serious challenge we face in the environment today. That is, of course, ridding our environment of dioxin, a deadly chemical which threatens the health and has disrupted the lives of many Missourians. I am most grateful that you've accepted this challenge to serve on the task force. It is a very timely meeting that we have today and there is much work to be done. As Fred indicated, as you know, yesterday the EPA and the federal task force on Times Beach proposed a buy-out for the residents of the Times Beach area. We are hoping also to have a similar conclusion to the Minker residence site, which will enable us to get to work immediately on the most pressing and most immediate problem, that is moving people from the sites from direct contact with dioxin or the likelihood of it. It will enable you to concentrate on the scientific responses which we must make on a longer term basis to the problems of dioxin. During the past few months, obviously, we have been bombarded with a great deal of information on this deadly chemical and what it means to the residents of many Missouri communities. I've had the opportunity over the last several months to visit personally with the people whose lives have been disrupted, whose families have been subjected to a great deal of concern over the presence of dioxin and to their fears as to what it might cause them in the future in the way of health and other problems.

In southwest Missouri where much of the dioxin was produced citizens are fearful there, however, on a continuing basis. Their streams and waterways may have been contaminated threatening wildlife, fish, as well as the health of area residents. In this area of the state where tourism is so very important we have to take strong action to ensure that clean waterways will continue to provide us with abundant fish, wildlife, and water supply. The people of southwest Missouri know that we are doing everything possible to protect the natural surroundings while we look for a way to remove permanently the threat of dioxin from their environment.

Or eastern side of the state, as you well know, families have been told to leave their homes to protect themselves from the health hazards of dioxin contamination in their yards and the streets of their communities. Gardens where once vegetables grew and children played are now empty because the fear of dioxin contamination has made citizens fear for their health and the health of their children in particular.

I believe the time has come for us now to provide some straightforward answers and a plan of action to combat the presence of dioxin in a way that will lower public anxiety and lead to some long-range permanent solutions. We were all very much relieved, as I indicated earlier, to hear that the residents of Times Beach will be offered a buy-out from the federal government. Yesterday I met with the leaders of the Missouri General Assembly to ask them for their approval and I've also asked the Missouri Legislature to provide our share of the cleanup and relocation expenses. The action at Times Beach and

what we hope will occur at the Minker residence site should help relieve the human suffering that these families have endured. Still, other families at other sites, discovered and yet to be discovered, await the answers that I hope this blue ribbon task force will find. That is a way to remove permanently the dangerous levels of dioxin from the soil in Missouri and to control dioxin where it is present in levels above that which is safe.

Let me provide you with a brief recount of the events which led up to our current situation. Let this be helpful for background for you and give you context within which to place your considerations. Fred Lafser and his staff will be providing you with more details on the work of the Department of Natural Resources. Dr. Hotchkiss will be giving you briefings on the health aspects and the determinations by the federal government, in particularly the Centers for Disease Control. Also, you will hear from Mr. Rice with the comments on the role of the Environmental Protection Agency, what they have done and what they seek to do in the future.

You might recall that last year, last December actually, after months of wrestling with this problem and sometimes making successful advances with the federal government and sometimes not, I went to Washington and met with top EPA officials personally and that meeting gave us the information that we needed to protect the health and safety of people in the Jefferson County area who had been exposed to dioxin contamination. We finally learned that the EPA's tests showed there that the levels of dioxin at the so-called Minker residence site were in sufficient quantities that the health experts believed that they were significant risks to the people living there. On December 8, I ordered that the state offer temporary relocation assistance to the families at the Minker site and the Division of Health was ordered to begin medical evaluations of the individuals who may have been exposed to the dioxin. I also reiterated my requests at that time that the EPA Superfund be used to find a permanent solution to the contamination of these areas and we requested that the EPA accelerate its testing process on samples from the sites identified potentially as dioxin sites throughout the state of Missouri.

After that as you well know the heavy rains of December added another and even more volatile dimension to the dioxin problem. Times Beach, the site of EPA testing for dioxin on road beds, had been virtually destroyed by severe flooding, 100-year floods which afflicted that area. As the flood waters were receding on December 23, just about Christmas Eve, the U.S. Department of Health and Human Services Center for Disease Control in Atlanta advised us that the pre-flood test samples of the Times Beach areas showed levels of dioxin that could be dangerous. The CDC recommended because of the uncertainties left behind in the mud and debris from the flood that non-emergency cleanup activities in Times Beach cease, that residents who had temporarily relocated stay out, and that residents who had already begun to move back in, leave. That day at my request the EPA agreed to send in new testing teams to conduct post flood dioxin tests. The federal Disasters System Center in Fenton, Missouri agreed to reopen on December 27 and stay open as long as necessary to help the Times Beach residents relocate. I then directed our Department of Public Safety, Division of Health to go back to Times Beach and assist with law enforcement and public health activities.

Since that time state officials have been working as they could with a variety of federal and local officials who assist with relocation plans, test sampling, and cleanup activities. As we developed a solution to the flood debris problem in Times Beach, however, as we continued to urge the EPA to

speed up its testing, it became clear that fragmented federal responsibility was becoming a substantial impediment to both emergency responses and long-term solutions. In some instances the recommendations and ideas of one particular federal agency did not square with the advice which was being given by other federal agencies. Therefore, I wrote and telephoned the White House to ask the President to immediately establish a federal task force to bring together all appropriate agencies and that a single federal agency and official be designated to take the lead responsibility in Times Beach. The President that same day appointed a federal coordinating group, task force, and named Lee Thomas of the Federal Emergency Management Agency as Chairman. The next day Mr. Thomas and I visited Times Beach and had discussions there and in St. Louis. We continued to work with federal officials to expedite their handling of the problems in all areas of Missouri. It appears that we are beginning to see some significant progress in handling the human problems associated with dioxin. Yesterday as we said the federal officials announced they would buy out the dioxin contaminated property in Times Beach, giving residents there a chance to move out permanently and to begin to rebuild their lives elsewhere.

Meanwhile the residents of the Minker site with whom I visited on Monday are still waiting for an answer to their problems. I strongly urged, and repeat that urging, that federal officials also buy out the homes at the site. We've been promised an answer three weeks from the time of that request which is about two weeks from today.

Unfortunately, as we all know, the Missouri dioxin problems do not stop at Times Beach or the Minker site or even the eastern Missouri sites. Because hazardous waste generators and haulers were unregulated for so many years in Missouri and elsewhere the problem of dioxin and other hazardous chemicals is likely to appear and re-appear throughout Missouri as it will throughout the nation for years to come. Extensive sampling and testing by the U.S. Environmental Protection Agency has confirmed the presence of dioxin at 22 sites in Missouri. I expect that more will be found as the testing continues on the some 80 to 90 sites identified as potential dioxin sites throughout the state. We really are in a situation where we have no precedent for solving this problem. No where else has there been found so much large volume of contaminated soil scattered at various locations under different conditions. That is why the state of Missouri needs your help to solve this complex problem. I ask you today to study very carefully all angles of the problem, keeping in mind the human suffering and the human health hazards that occur, as well as the dangers to the environment, and recommend to me solutions that are practical and technologically sound. To this end I request that you examine and evaluate all known methods, processes and technologies for the destruction and containment of dioxin as it exists as a contaminant in soil and stream sediments at various locations in Missouri. I also ask that you investigate the costs of each of these methods and the length of time required to take remedial action. To the extent possible, I would suggest that you coordinate your study with the ongoing investigations and studies of the U.S. Environmental Protection Agency. Yesterday, Mr. Hedeman in announcing the Superfund activities said that the EPA will be working with the state of Missouri to develop means of controlling, destroying, and containing dioxin. You may want to visit some of the sites where cleanups are underway or the sites where innovative solutions are being tested. Fred Lafser has already pointed out that we have already discovered through the efforts of Syntex some means of destroying dioxin where found in highly concentrated forms and we

have some expertise which has already been developed in this area. I am confident that the problem can be solved but it will only be solved by cooperative effort by state, local and federal agencies. At several of the larger sites, obviously, if extensive cleanup is required to protect the health of citizens, we are going to need federal Superfund assistance once again. We also are going to need the assistance of the best knowledge, the best ability, in the private sector. The number of nationally known companies with a reputation for helping solve dioxin problems have written to state government and suggested ideas for dealing with the dioxin problem. I am sure that they would be willing to discuss these ideas with you. We hope that from these sources and other sources which will be available to you, we will be able to come up with some answers. Again, Mr. Lafser and his staff will be able to assist you in your task.

The heart, of course, of the dioxin problem is the human health problem. There has been a great deal of confusion and anxiety regarding the public health dangers associated with dioxin, particularly as it exists as a contaminant in soil and stream sediments in locations throughout Missouri. I'd ask that you examine the data, the analyses provided by the Federal Centers for Disease Control and the Missouri Division of Health. Based on this examination I'd like you to assess for us the public health dangers of dioxin contamination and recommend what other services the state should be providing. Bob Hotchkiss of the Division of Health will be presenting information on these issues this morning and he and his staff will be able to assist you in that part of the assignment.

You should also be aware that I have recommended to the Missouri General Assembly legislation to help combat the dioxin problem. I think some of these actions represent the basic commitments that our state must make. I proposed in January an immediate $1 million in emergency appropriation for immediate relocation of families and cleanup activities. As I mentioned earlier, I have just yesterday urged the General Assembly to appropriate on an emergency basis another $3.5 million for the state match for the buy-out of the Times Beach property and relocation of citizens from that area.

Second, I have proposed that we immediately add five new environmental health officers to the Division of Health on an emergency basis and add two more environmental health officers next year.

Third, we proposed the hiring of a hazardous waste criminal investigator and three environmental landfill specialists to the staff of the Department of Natural Resources so that we may follow up and investigate suspicious circumstances and proceed with prosecution of anyone violating our hazardous waste laws.

Fourth, I've proposed an expansion of the Missouri Superfund, increasing fees on hazardous waste generators, transporters, and waste site operators, to provide us with the mechanisms and the resources to deal with these problems.

As you see the fifth proposal I made to the legislature was the Governor's Task Force of scientific advisors and concerned citizens, the long-term solution, and that is you, ladies and gentlemen. When I said we were going to get a blue ribbon task force, I was generally aware that we had some very unusual and special talents in this state and your presence here today, your willingness to serve and your dedication to these efforts convinces me that we do have the resources in our state that we need to solve the problem.

I'm happy to report that the bills that have been recommended are progressing in the General Assembly and with passage of the legislation we

should be able to provide some immediate relief and establish the groundwork for better management of hazardous waste in the future. In the meantime, I turn to you for your help in identifying the permanent comprehensive solutions to the dioxin problem in Missouri. Make no mistake about it, this is a serious and difficult challenge. The nation is watching to see how Missouri will solve the dioxin problem we have here. We must show that we are up to the challenge and prepared to emerge as a national leader in responding to hazardous waste problems. Missouri is not the only state that has hazardous waste problems. They have a particular problem because of the way in which the dioxin was spread across our state and it is a particularly difficult challenge, but the expertise, the knowledge and the information we gain here not only can help the citizens of our state, but I believe can help provide some ideas and leadership for other states in the nation as they too must face their hazardous waste problems.

In the end I trust that we will not only solve the problem, but will restore pride that we have in our state, a pride that has been sagging in some areas in recent months as we have seen on television and heard on the radio and read in the newspapers as the nation has focused on our dioxin problems. When we have found those solutions, Missourians will thank you for the important role that you have played. Today once again, I extend my sincere thanks to you for your agreement to accept this responsibility. I've asked for your time, your dedication, your patience, and your expertise. That combination I am convinced will enable us, in cooperation with the other agencies and the other entities involved, to come up with the solutions that we must have.

EXECUTIVE SUMMARY

TASK FORCE RECOMMENDATIONS

This interim report is not limited to Times Beach, but has been expanded to include the Minker/Stout site because this later site is considered to be unstable since movement of contaminated soil is occurring. Following is a summary of the actions that are needed to deal with the problem at these sites. The final report will deal with the problem as it exists statewide.

MINKER/STOUT

-the buyout should be expedited.
-access to the site should be restricted.
-initial stabilization measures should be implemented.
-surface and groundwater sampling should be conducted.
-planning for final remedial action should continue with all deliberate speed.
-more complete health studies should be considered.

TIMES BEACH

-the buyout should be expedited.
-access to the site should be restricted.
-additional sampling of the surface and groundwater should be conducted.
-other than limiting access, no initial remedial actions are recommended unless contaminant migration is found.
-additional soil sampling should be done to determine extent and depth of the concentration.
-more complete health studies should be considered.

AVAILABLE TECHNOLOGY

-test burn soils with varying concentrations of TCDD to demonstrate destruction by incineration and to determine if the ash is non-hazardous.
-continue study and research on solvent extraction and fixation.
-locate site for a storage treatment facility.
-landfilling is to be used only as a last resort.

FURTHER RESEARCH

-the human health effects of dioxin.
-the health of residents of contaminated sites.
-the bioavailability of dioxin in soil.
-stability and transport of dioxin in the environment.

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INTRODUCTION

TASK FORCE ACTIVITY

For the past four months, the Dioxin Task Force, appointed by Governor Bond, has conducted an intensive study of the dioxin situation in Missouri. The Task Force has heard testimony and reviewed studies made by experts from throughout the country regarding the environmental and health effects of dioxin. The Task Force also has conducted a study of available technology for disposal of dioxin and has made an assessment of those technologies based on applicability to the specified sites being considered in this report.

As requested by Governor Bond, the recommendations in the interim report deal specifically with the Times Beach site. In addition, the Task Force also related all available information to the Minker/Stout site, another area of high priority. While many recommendations made will be applicable to other sites in Missouri, detailed discussion of those sites will not be made until the final report due in October.

HISTORICAL SUMMARY

In 1969, the North Eastern Pharmaceutical and Chemical Company (NEPACCO) began producing 2,4,5-trichlorophenol (2,4,5-TCP) as an intermediate for hexachlorophene in a Verona, Missouri manufacturing facility leased from the Hoffman-Taff Chemical Company and later Syntex Agribusiness Inc. In the manufacturing process, the product stream was distilled and filtered to remove impurities. Dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin or TCDD), which was formed in trace quantities during the manufacturing process for the TCP, was removed from the product during filtration and distillation. The filtration and distillation residues thus became contaminated with dioxin. Unfortunately, it was not known at the time the still bottoms contained TCDD.

Missouri's current dioxin dilemma can be traced to May 1971. At this time the problem came to the attention of state and federal officials when a child was hospitalized after playing in a horse arena where numerous horses and other animals had become ill and died. Between 1971 and 1974 officials of the Missouri Divison of Health (DOH) and the federal Centers for Disease Control (CDC) conducted an investigation to determine the cause of these problems. In the investigation, it was discovered that some additional people were ill and that several stables had been sprayed in 1971, as a dust control measure, by Russell Bliss, a waste oil hauler from St. Louis. It was not until July of 1974 that it was determined that a toxic form of dioxin (TCDD) was the causative agent in the oily wastes. Until that time, there was neither reason to suspect that TCDD was involved, nor reason to link these problems with NEPACCO's manufacturing processes in Verona, Missouri a few years earlier.

Meanwhile, the contaminated soil at the horse arenas had been removed by the owners of the arenas and disposed of in various locations. Some of the contaminated soil from the Bubbling Springs arena in Fenton was used as fill material at the Minker and Stout residences in Jefferson County.

On August 2, 1974, the CDC informed the Division of Health that dioxin had been found in the samples collected at the Shenandoah Arena (31.8 to 33 ppm). The CDC then accepted the invitation of Dr. Denny Donnell, state epidemiologist, to participate in a renewed investigation. Dr. Patrick Phillips, of the Division of Health, and Drs. Coleman Carter and Matthew Zack (CDC) began an intensive investigation of the problem.

On August 11, 1974, Dr. Phillips met with Judy Piatt, owner of the Shenandoah Arena, to explain the toxic effects of TCDD and to refer the exposed persons to family physicians for evaluations. On August 13, Phillips learned that the Bubbling Springs arena also had experienced similar horse illnesses. On August 14, 1974, Dr. Phillips interviewed persons connected with Bubbling Springs and obtained information about animal and human illnesses; he also obtained information about sites where the excavated arena soil had been taken (Minker and Stout residences). Phillips interviewed Vern Stout and Valerie Minker on August 14 concerning soil excavated from the Bubbling Springs Ranch arena and learned that the soil was deposited at the Minker residence in March 1973. He informed both persons of probable dioxin contamination and obtained samples of soil for analysis. Test results later showed the soil from the Minker residence to contain 0.74 ppm dioxin and soil from the Stout residence to contain 0.44 ppm dioxin.

The dioxin investigation continued in August and September of 1974 and the toxic wastes were traced to their origin at the Syntex plant in Verona. It was discovered that NEPACCO had bought equipment and leased plant space from Hoffman-Taff (since acquired by Syntex Agribusiness, Inc.) and had used Bliss Waste Oil for disposal of some of its wastes. It also was learned that a tank containing approximately 4,300 gallons of distillation residue wastes from NEPACCO's operation still existed on Syntex plant property at Verona. Tests later showed that TCDD was highly concentrated in the tank's contents at approximately 350 ppm.

For the next few years this tank containing high concentrations of TCDD became the chief concern and focal point of activity on the Missouri dioxin issue. On October 2, 1974, Dr. Clark W. Heath, Jr., director of the Cancer and Birth Defects Division, Bureau of Epidemiology, CDC, wrote a letter to Dr. Denny Donnell, Jr. at the Missouri Division of Health, emphasizing the definite hazard of the wastes at the tank in Verona: "...it is important for the public safety that this material be promptly and safely destroyed." This letter apparently served to focus the attention of state officials on the potential hazard of the wastes in the tank at Verona. Health recommended incineration of wastes from the tank and deep burial of the tank itself.

The final CDC report on the investigation (March 1975) pointed out that the expected half-life* of dioxin was one year and recommended: a) that inaccessible contaminated soil remain undisturbed; b) that soil in residential fills be removed to a landfill; c) that the contents of the storage tank (at Verona) be properly incinerated; d) that the tank be marked and deep buried; and e) that symptomatic persons be followed up. This report was reviewed by

*For a discussion of the term "half-life," see Chapter 7.

the DOH and transmitted to the Missouri Department of Natural Resources (DNR). Because of earlier CDC advice, Missouri officials focused on items c) and d). All symptomatic persons were known to be under medical care.

The recommendation to remove contaminated soil from residential locations was discussed by DNR and DOH. In light of the knowledge of the expected half-life of dioxin in soil in 1975, levels approaching minimum detectable limits at that time, and the apparent stability of the sites, it appears that a decision was reached not to remove the soil but to resample in an effort to confirm the anticipated degradation rate of dioxin. Dr. Phillips visited the residential sites in September 1976; he confirmed that the soil was not eroding and that vegetation had been established, and he took additional samples which were sent to the CDC lab. (Results were obtained in a phone conversation between Dr. Phillips and Dr. John Liddle, head of the CDC Lab, on November 22, 1982.)

From October 1974 to August 1977, there were many frustrating attempts to find a method for incinerating the wastes from the tank in Verona. In August 1977, Syntex officials reported on a new photolysis process which could detoxify dioxin. Essentially, this process involved breaking down compounds with ultraviolet light. Continued investigation showed this to be a preferable method of destruction, and in September 1979, a final decision was made to use the photolysis method. By August 1980, virtually all the 4,300 gallons of waste had been processed. Nearly 13 pounds of dioxin had been destroyed, reducing the original 343 parts per million dioxin content by more than 99 percent. Syntex had become the first company to successfully and safely degrade large amounts of dioxin by photochemical means.

While the Verona tank problem was being solved,the EPA received an anonymous call alleging that other sites in the southwestern part of the state had received NEPACCO wastes. Follow-up investigation led to the discovery of the Denney Farm site; Baldwin Park in Aurora; the wastewater treatment school in Neosho; the Crider, Erwin, Ray, and Rusha farm sites near Verona, and the potential dioxin contamination of the Spring River.

Beginning in October 1979, attention was focused on the Denney Farm cleanup. The actual cleanup, conducted by Syntex with EPA approval, began in September 1980 and was completed in the summer of 1981.

In January 1981, the wastewater treatment school at Neosho was sampled; certain areas were secured and partially cleaned up by EPA.

In November 1981, Ron Crunkilton of the Missouri Department of Conservation and Dan Harris of EPA collected fish from the Spring River to be tested for dioxin. Preliminary test results received in February 1982 indicated the presence of dioxin in the fish tissue. The Missouri Department of Natural Resources, Division of Health, Department of Conservation, and the EPA conducted public meetings in March 1982 to announce the fish sampling results and issued an advisory to limit consumption of fish from the Spring River.

Also, in early 1982, EPA officials announced their intention to resample the horse arenas and the associated sites where excavated soil had been placed. This sampling took place in May and June 1982; the results were obtained in August and made public on August 18. Subsequent events leading to intensive sampling of numerous sites in eastern Missouri are well known. The recent buy-

out of the residents of Times Beach has made national headlines out of Missouri's dioxin problem.

Overall, the 11-year-long investigation of dioxin had several phases:

May 1971 - August 1974

Phase I: First appearance of animal and human health problems at horse arenas and investigation determining that dioxin in wastes from the plant at Verona had been the cause.

October 1974 - October 1979

Phase II: Attention focused on the highly contaminated wastes in a tank at the Verona plant and the search for methods to destroy the dioxin in the tank.

October 1979 - April 1982

Phase III: Discovery and investigation of numerous sites in southwest Missouri including Denney Farm site and Spring River.

May 1982 - Present

Phase IV: Resampling of horse arenas and associated sites and investigation of new leads in eastern Missouri. Continued sampling of the Spring River and examination of other potential dioxin sites in southwest Missouri.

In Phase I, the investigation was primarily conducted by the Missouri Division of Health and the Centers for Disease Control.

As a result of state reorganization, the Missouri Department of Natural Resources was established on July 1, 1974. DNR established a hazardous waste project in January 1975 and initiated a major survey of hazardous waste generators in the state in order to determine the type and quantity of waste being generated.

DNR, DOH, and EPA cooperated during the Phase II efforts to find a method of destroying the wastes in the tank at Verona. From January 1975 through June 1977, DNR's primary emphasis, however, was on research and legislative activities leading to the passage of the Missouri Hazardous Waste Management Law in 1977 and later amendments in the Special Session of 1980. From July 1977 to the present, DNR's primary activity in hazardous waste has focused on the development and implementation of regulations to prevent mismanagement of currently generated hazardous wastes. However, DNR also has been increasing its assistance to EPA in the investigation and clean-up of abandoned and uncontrolled hazardous wastes sites, particularly since the 1980 amendments to the state law where authority for clean-up and some funding were provided. In fact, a 1980 report to the Governor prepared to support the legislation indicated there were approximately 100 such sites in Missouri.

In Phase III, the EPA was clearly in the lead in the investigation of newly discovered sites in southwest Missouri, and EPA continues as the lead agency in Phase IV with assistance from state agencies and other federal agencies. The

passage of the federal "Superfund" Law in December 1980 greatly augmented the EPA's ability to investigate and cleanup abandoned and uncontrolled hazardous waste sites.

Some controvery has resulted from the March 31, 1975 CDC memo which, among other things, recommended excavation of fills at Minker and Stout sites. Although the records are not definitive and most of the personnel involved are no longer with state government, it is inferable from the facts at hand that state officials chose to concentrate their rather limited staff resources on the Verona tank wastes for several reasons:

1. The very high levels of dioxin in the tank at Verona.

2. The assumption that the TCDD in the tank would never degrade.

3. The advice from CDC and other sources that TCDD in the soil at other sites would degrade relatively quickly with probable half-life between 0.24 and 1.0 years.

4. The lack of a disposal or detoxification method for large volumes of soil.

5. The lack of clearly defined clean-up authority.

6. Lack of clean-up funds and staff for investigation and follow-up.

7. An assumption that the contaminated soil of Minker/Stout was stabilized and would not erode onto neighboring properties. Thus, as far as state and federal officials knew, all relevant parties had been notified when the Minker and Stout families were notified in 1974.

8. Less precise methods of measuring TCDD than are now available.

9. At Verona, a private party (Syntex) existed who was willing to provide money and expertise.

The dioxin issue in Missouri has been clouded with a lot of unknowns and controversies. Consider that the work extended for five years over how to detoxify the 4,300 gallons of concentrated material in the Verona tank that NEPACCO left behind. What to do with the dioxin-laced soils still is a question today and illustrates the frustrations and limited options available.

Overall, history shows the clear need for the statutes which were passed in the late 1970s and early 1980s. Legislators acted first to prevent new problems from the mismanagement of hazardous wastes. Then statutes were enacted to authorize clean up of the old abandoned and uncontrolled waste sites. Passage of the federal "Superfund" law has boosted efforts to clean up these dumps. Through adequate enforcement of the waste management laws now on the books, Missouri can prevent problems like the dioxin dilemma from ever happening again.

DIOXIN INVESTIGATION: CURRENT STATUS

The Missouri dioxin investigation began in the spring of 1971 when various parties began a search for the cause of animal deaths at a horse arena. After the problem was traced to dioxin in the summer of 1974, the investigation was

focused on locating the source of the contaminant. The dioxin was quickly traced to the former North Eastern Pharmaceutical and Chemical Co. (NEPACCO) plant at Verona. It further was determined that the Bliss Waste Oil Co. had been subcontracted to dispose of wastes from the site, but instead mixed the wastes with used oil and sprayed several locations for customers as a dust control measure.

During the next several years, the investigation continued in the southwest Missouri area. Government officials concentrated on finding the means to destroy a large tank of highly contaminated material that was left by NEPACCO at its former plant site, a facility since purchased by Syntex Agribusiness Inc. Investigators worked to locate other areas nearby where dioxin-contaminated wastes were reported to be buried.

The pace of the investigation picked up dramatically in the summer of 1982 when results of an Environmental Protection Agency (EPA) testing program indicated that the dioxin molecule is far more persistent in the environment than originally thought. From late summer until mid-January 1983, the Environmental Protection Agency committed substantial resources to locate and document potential dioxin sites in the eastern Missouri area, while still maintaining efforts as necessary in southwest Missouri. Sampling was arranged where indicated. Some assistance was provided by specially assigned personnel from the Department of Natural Resources, who worked under the EPA's direction.

In mid-January, as a result of the increasing number of sites where follow up was required, the Department of Natural Resources' Division of Environmental Quality did assign personnel to coordinate a state investigation and complement the federal effort. The state and federal investigation coordinators agreed that the EPA would continue to handle primarily sites in southwest Missouri while state personnel would assist with the rapidly expanding caseload in eastern Missouri. During the major portion of the recent state and federal investigation, a combined force of about five persons has been following up on leads, interviewing, taking statements, seeking access permission, sketching and photographing sites, and outlining suspect areas in preparation for sampling. As new leads are acquired, the coordinators decide who will assume responsibility for followup.

An original list of 40 suspect sites has grown quickly, with changes occurring so fast that it is difficult to provide an accurate report on the status of the investigation. On a daily basis, sites are confirmed, new leads are acquired, old leads are found groundless, and sometimes one site becomes two.

Investigators are looking for information about sites that may have been sprayed by the Bliss Oil Co. with waste oil or other material at some point after May 1971. Sites sprayed close to this time are of greatest concern. Leads have been provided by arena owners, former Bliss employees, concerned citizens, and the state's "dioxin hotline". Investigators even pickup leads in the course of casual conversations. All leads are taken seriously and scheduled for followup according to their apparent value and risk posed to human health and the environment.

As of May 26, there were 31 sites in the state where dioxin contamination has been confirmed. An additional 102 sites were under investigation. There were 76 sites that have been investigated and determined by EPA to require no further action at this time.

CHAPTER 1

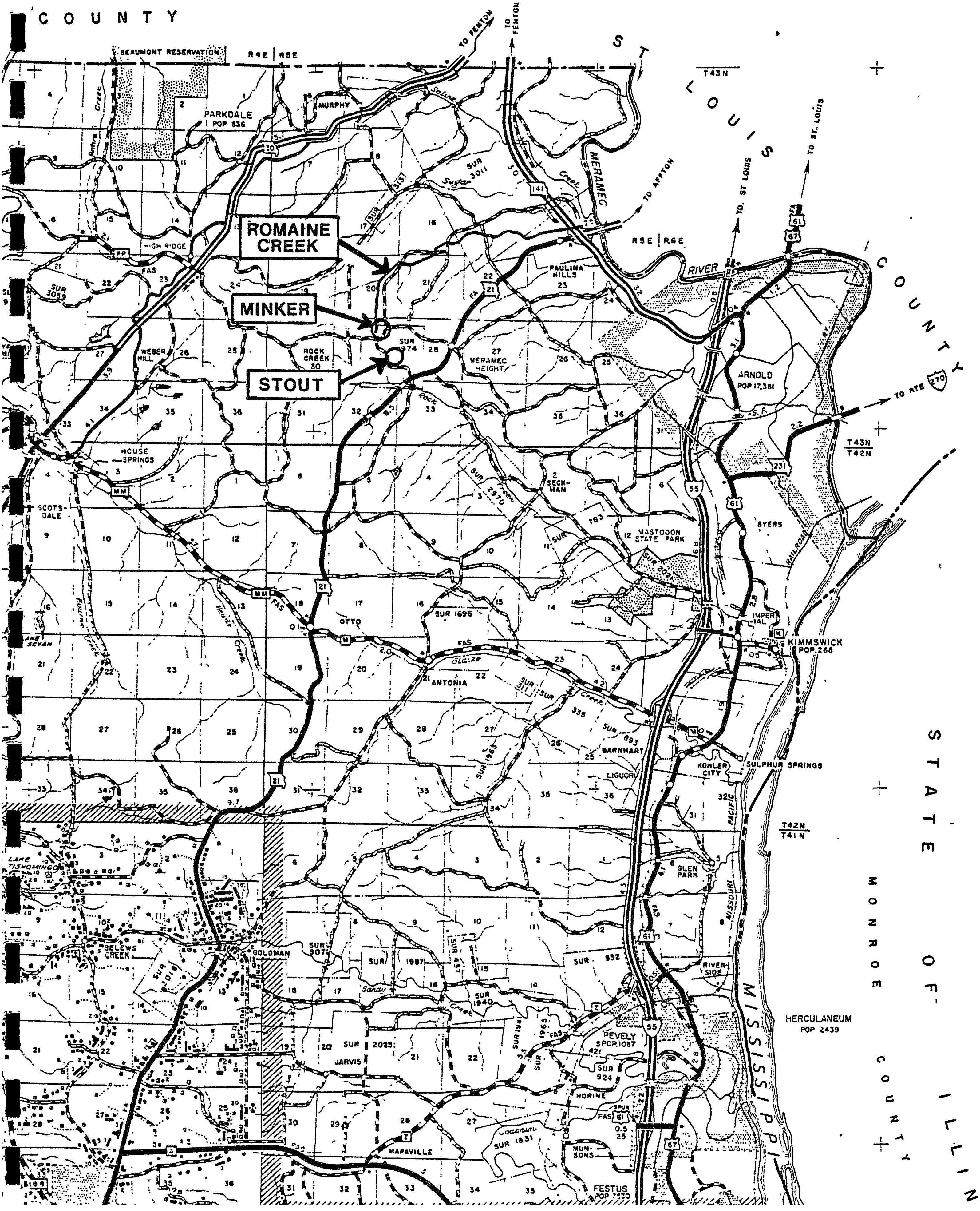
SITE SUMMARIES

This report contains specific information on the Minker/Stout/Romaine Creek and Times Beach sites. Therefore, this chapter presents information for these sites:

Location
Accessibility
Historical Summary
Site and Contaminated Area Description
Geologic and Soils Description
Unique Site Characteristics

Site maps for the Minker, Stout, and Romaine Creek sites were taken from information presented to the Task Force by CH_2M Hill, which is contained in Appendix VII. CH_2M Hill is EPA's feasibility contractor for the Minker/Stout sites.

Location maps and brief summaries of the present 31 confirmed dioxin sites are contained in Appendix VI. As the above information is compiled for all of the confirmed dioxin sites, it will be included in the final report.



COUNTY
ST LOUIS COUNTY
STATE OF ILLIN
MONROE COUNTY
BEAUMONT RESERVATION
R4E R5E
R5E R6E
T43N
T43N T42N
T42N T41N
TO FENTON
TO AFFTON
TO ST LOUIS
TO RTE 270
ROMAINE CREEK
MINKER
STOUT
PARKDALE POP 836
MURPHY
HIGH RIDGE
PAULINA HILLS
MERAMEC
RIVER
ROCK CREEK
MERAMEC HEIGHT
WEBER HILL
HOUSE SPRINGS
SCOTSDALE
ARNOLD POP 17,381
SECKMAN
MASTODON STATE PARK
BYERS
OTTO
ANTONIA
IMPERIAL
KIMMSWICK POP 268
BARNHART
KOHLER CITY
SULPHUR SPRINGS
LIGUORI
GLEN PARK
LAKE TISHOMINGO
BELEWS CREEK
GOLDMAN
RIVERSIDE
HERCULANEUM POP 2439
PEVELY POP 1087
JARVIS
HORINE
MAPAVILLE
MUNSONS
FESTUS
MISSISSIPPI
MISSOURI PACIFIC
RAILROAD

SiteNotes AERIAL
OVERALL OVERALL

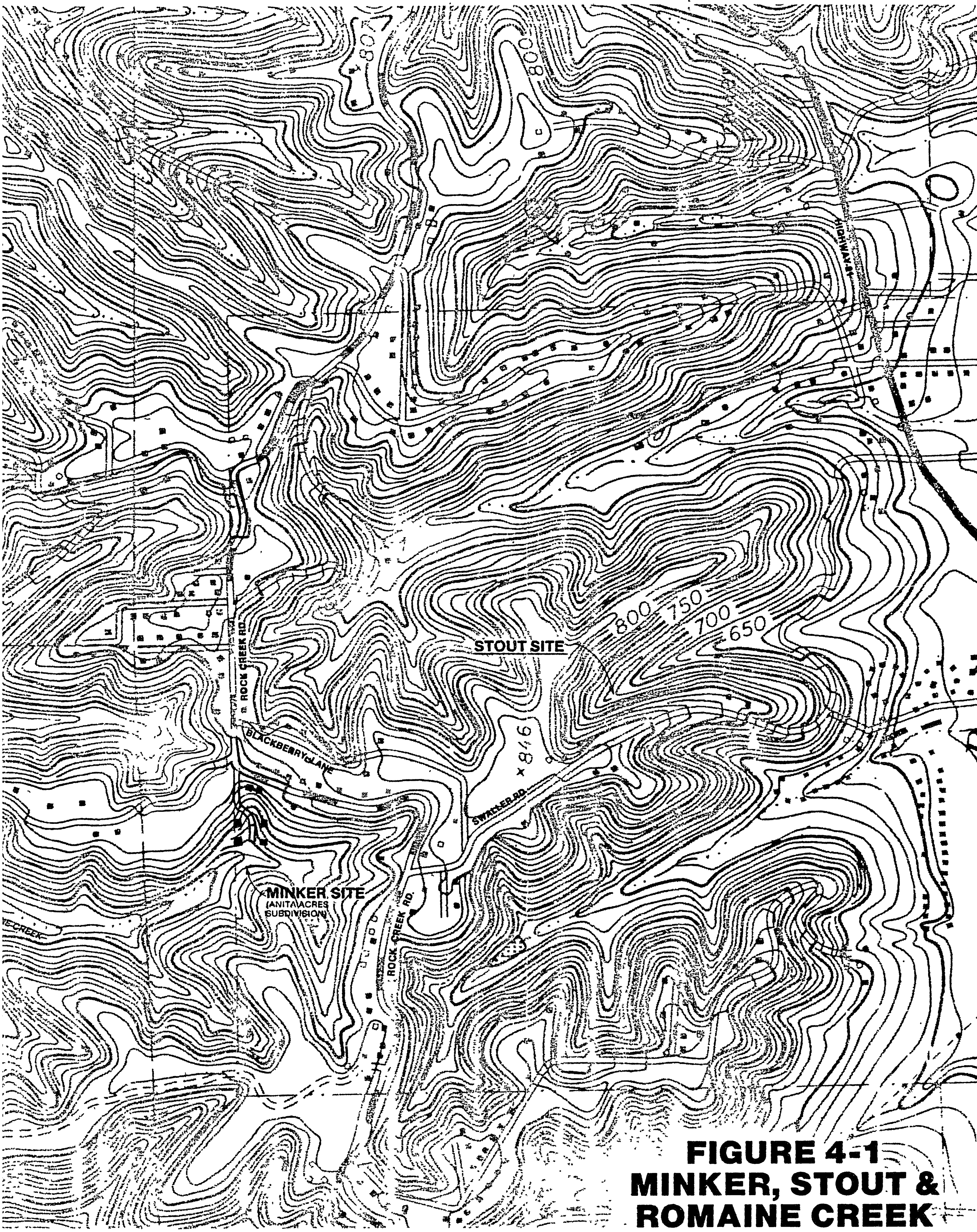


**FIGURE 4-1
MINKER, STOUT &
ROMAINE CREEK
SITE MAP**

MINKER RESIDENCE

Location

Legal Description: Anita Acres, a resubdivision of the north half of Lot 35 of Sunset Acres Subdivision in U.S. Survey No. 1974

By extrapolation of section lines: SE 1/4, NE 1/4, NE 1/4, Section 29, T. 43 N., R. 5 E., 5th P.M.
Maxville Quadrangle
Jefferson County
Latitude: 38^{o} 26' 25"
Longitude: 90^{o} 28' 10"

Address: 4037 West Rock Creek Road
Imperial, Missouri 63052

Accessibility

Access is west approximately 1.3 miles from Missouri Highway 21 on West Rock Creek Road, or northwest approximately 1.3 miles from Missouri Highway 21 on Swaller Road and West Rock Creek Road. West Rock Creek and Swaller Roads are low type bituminous.

History Summary

In June 1971, the Bubbling Springs Ranch horse arena was sprayed with contaminated waste oil. After several incidents of horse illnesses, the arena owner hired a private contractor to remove the soil which was suspected to be causing the problems. In March 1973 about 850 cubic yards was excavated, of which an estimated 260 cubic yards was used for fill at the Minker residence. The Center for Disease Control sampled the site in 1974 and found levels of 2,3,7,8-TCDD ranging from 85 ppb to 740 ppb. This site along with Romaine Creek and the Stout Site is included on the National Priorities List. A State Superfund contract has been signed with the State for these three sites. The contract covers relocation and a feasibility study for the sites.

Site Description (see maps)

The Minker Site lies at the head of Romaine Creek. The Minker house sits near the top of a ridge and the fill area is immediately to the south of the house. The toe of the fill abuts the neighboring yard. The fill was placed in a gully which carries storm drainage to Romaine Creek. Apparently, the fill began to erode almost immediately and most of the fill has now eroded downslope. Hence, the contaminated soil has been widely spread around other residences' yards downslope and into Romaine Creek. EPA sampling during 1982 and 1983 found 2,3,7,8-TCDD levels up to over 300 ppb. Volume of material has been estimated at 5000 to 8000 cubic yards for the Minker and Stout Sites combined.

Several homes are located across West Rock Creek Road from the Minker site. Testing has revealed no TCDD contamination of these properties.

Geologic and Soils Description

The Minker Site is in an upland setting underlain primarily by residual soil derived from weathering of a cherty limestone. A surface veneer of loess is present in limited areas and is usually not a factor in construction projects in the area.

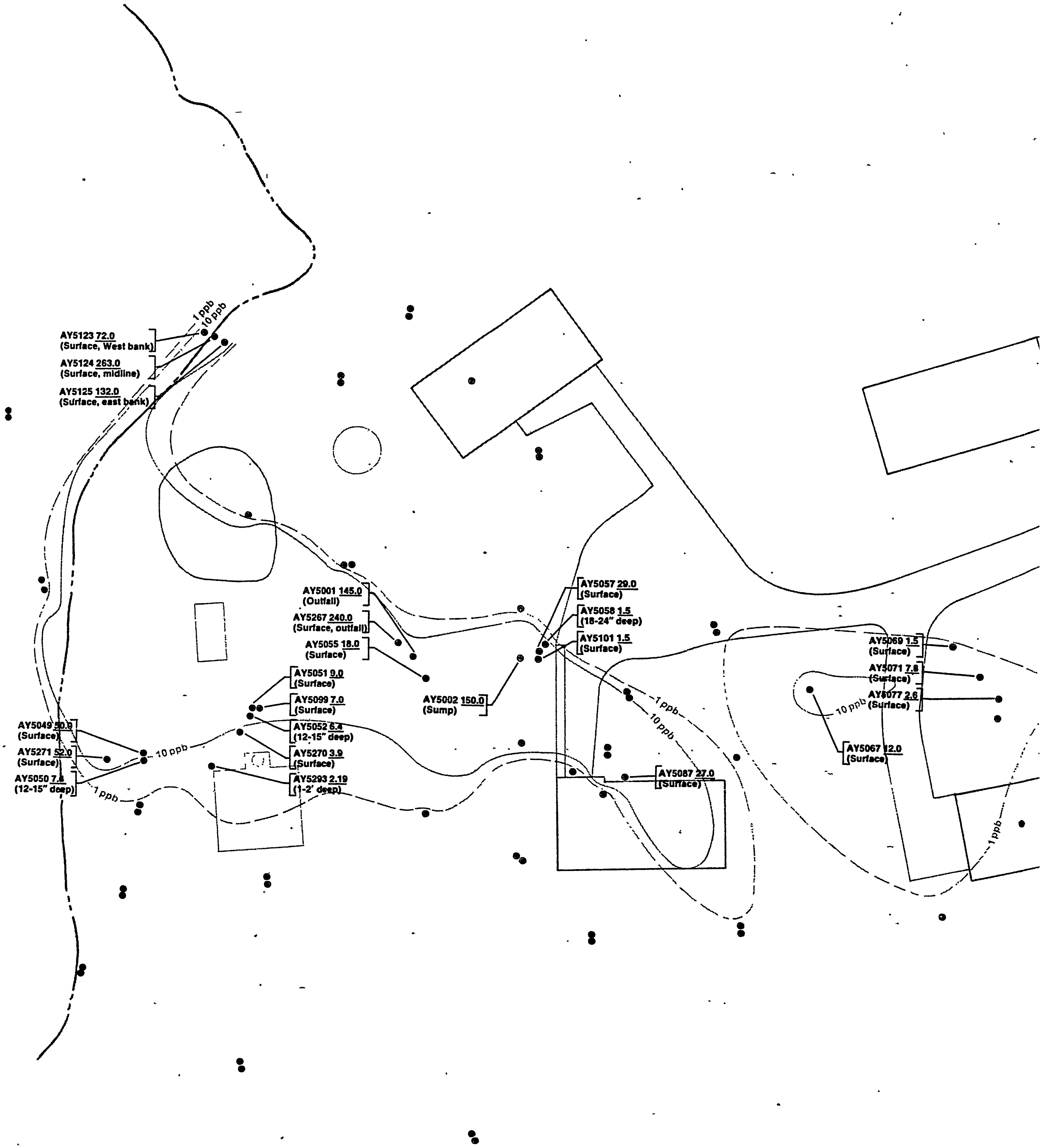
The thickness of the residual soil can range from a few feet upwards in excess of 80 feet. For an average thickness, an assumption of 20 feet is valid for residual soil on the uplands and hillslopes. The clay portion in this soil could be as high as 40% or 50% with most of the remainder of the fine textured portion being made up of silt. The coarser fraction consists of angular to subangular chert fragments and these may range from 10% to as much as 40% of the soil deposit.

The Romaine Creek valley contains material eroded from the residual soil on the hillslopes. Thus, most of the alluvial material is a chert gravel material, with the surface soil being silt rich. The Bubbling Springs horse arena is located on the floodplain of the Romaine Creek.

In conclusion, the contaminated material used as fill at the Minker Site was similar to the residual soil, but having a higher silt content. Due to being spread out by erosion and mixed with residual material, the contaminated soil is primarily a stoney clay.

Unique Site Characteristics

The Minker Site is located in a dramatic topographical area which will complicate any construction or remedial activity. The contaminated material was located in a residential area, in yards and readily accessible to humans. The material is spreading through a large area (Romaine Creek), greatly enlarging the affected area.



1 ppb
10 ppb
AY5123 72.0 (Surface, West bank)
AY5124 263.0 (Surface, midline)
AY5125 132.0 (Surface, east bank)
AY5001 145.0 (Outfall)
AY5267 240.0 (Surface, outfall)
AY5055 18.0 (Surface)
AY5002 150.0 (Sump)
AY5057 29.0 (Surface)
AY5058 1.5 (18-24" deep)
AY5101 1.5 (Surface)
AY5051 9.0 (Surface)
AY5099 7.0 (Surface)
AY5052 6.4 (12-15" deep)
AY5270 3.9 (Surface)
AY5293 2.19 (1-2' deep)
AY5049 50.0 (Surface)
AY5271 52.0 (Surface)
AY5050 7.8 (12-15" deep)
10 ppb
1 ppb
AY5087 27.0 (Surface)
1 ppb
10 ppb
AY5069 1.5 (Surface)
AY5071 7.8 (Surface)
AY5077 2.6 (Surface)
10 ppb
AY5067 12.0 (Surface)
1 ppb

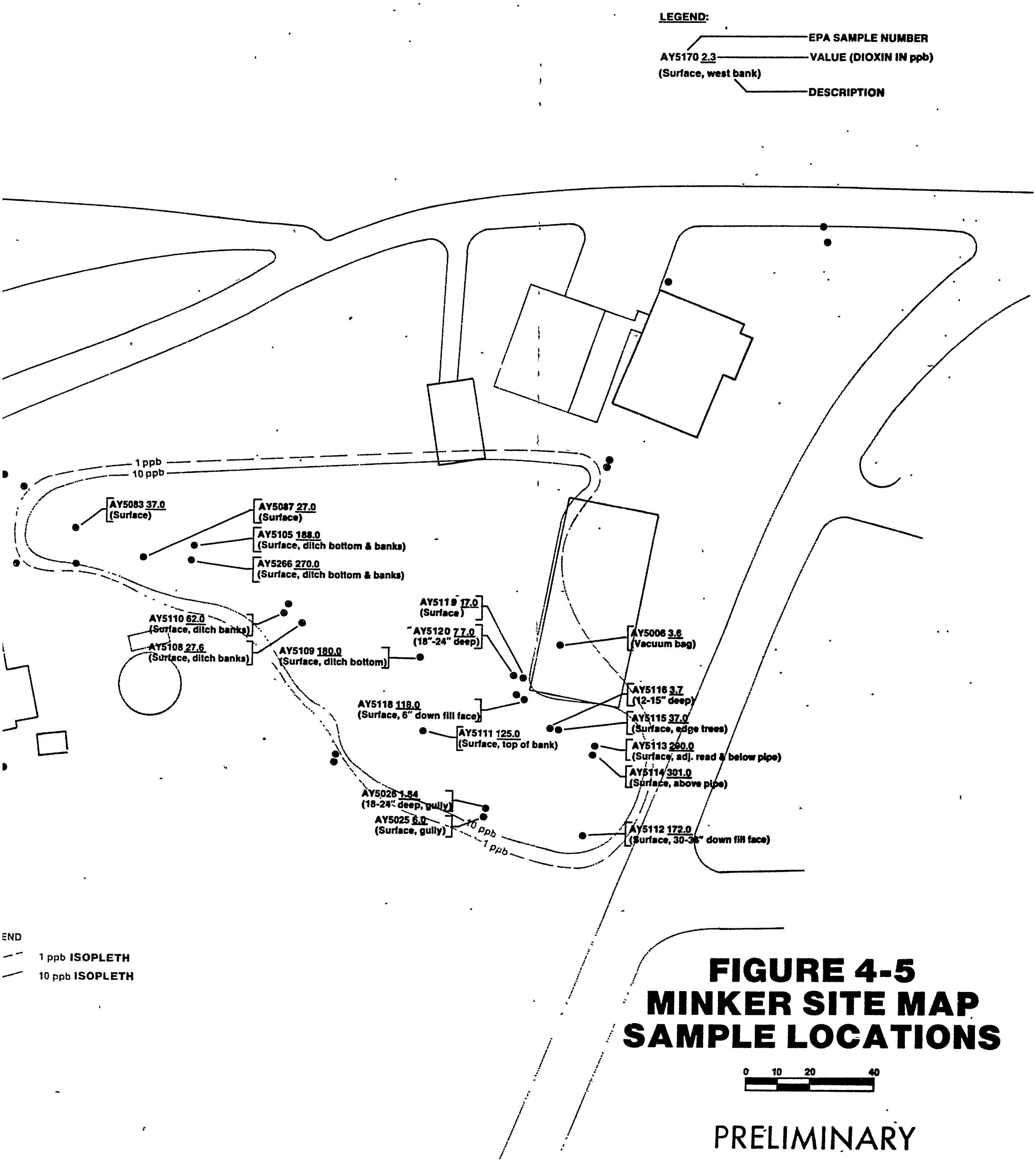


FIGURE 4-5
MINKER SITE MAP
SAMPLE LOCATIONS

PRELIMINARY

STOUT RESIDENCE

Location

Legal Description: U.S. Survey No. 1974

By extrapolation of section lines: SW 1/4, NE 1/4, SE 1/4
Section 29, T. 43 N., R. 5 E., 5th P.M.
Maxville Quadrangle
Jefferson County
Latitude: 38° 26" 0"
Longitude: 90° 28' 05"

Address: West Swaller Road
Imperial, Missouri 63052

Accessibility

Access to the site is northwest approximately 0.7 mile from Missouri Highway 21 on Swaller Road. Swaller Road is low type bituminous.

History Summary

In June 1971, the Bubbling Springs Ranch horse arena was sprayed with contaminated waste oil. After several incidents of horse illnesses, the arena owner hired a private contractor to remove the soil which was suspected to be causing the problems. In March 1973 about 850 cubic yards was excavated, of which the majority was used for fill at the Stout Site. The Center for Disease Control sampled the site in 1974 and found levels of 2,3,7,8-TCDD in the range of 170 ppb to 440 ppb. This site along with Romaine Creek and the Minker Residence Site is included on the National Priorities List. A State Superfund contract has been signed with the State for these three sites. The contract covers relocation and a feasibility study for the sites.

Site Description (see maps)

The Stout Site sits slightly to the east side of a north-south ridge. The fill material was used to make a level lot for two trailer pads. Reportedly, the fill operation was already in progress when the contaminated soil was brought to the site. Contamination was found throughout the fill by EPA sampling at levels from 1.0 ppb to 300 ppb, down to a depth of 20 feet. It is believed that 20 feet is the maximum depth of fill at any point. Volume of material has been estimated at 5,000 to 8,000 cubic yards for the Minker and Stout Sites combined.

Geologic and Soils Description

The Stout Site is in an upland setting underlain primarily by residual soil derived from weathering of a cherty limestone. A surface veneer of

loess is present in limited areas and is usually not a factor in construction projects in the area.

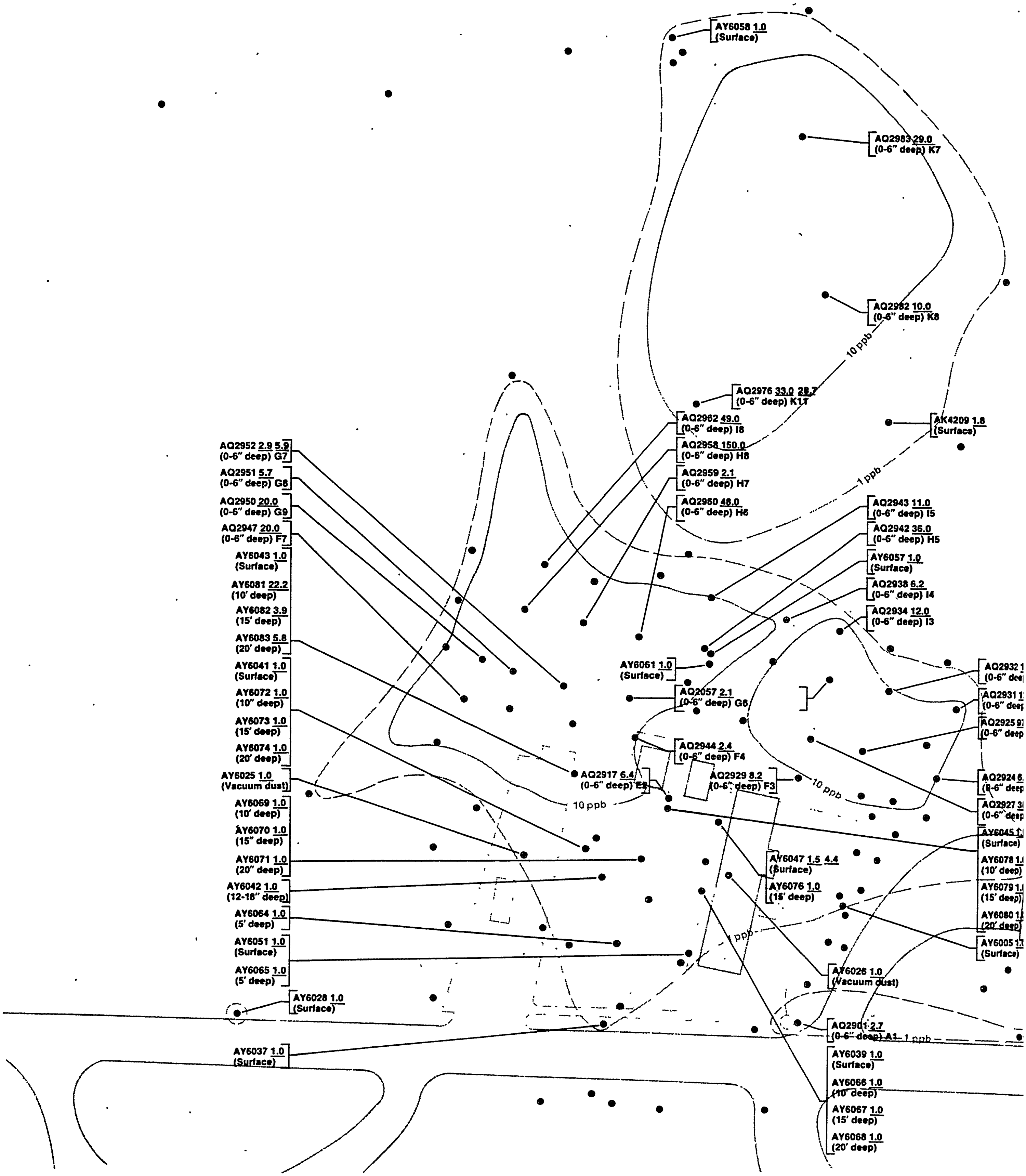
The thickness of the residual soil can range from a few feet upwards in excess of 80 feet. For an average thickness, an assumption of 20 feet is valid for residual soil on the uplands and hillslopes. The clay portion in this soil could be as high as 40% or 50% with most of the remainder of the fine textured portion being made up of silt. The coarser fraction consists of angular to subangular chert fragments and these may range from 10% to as much as 40% of the soil deposit.

Surface runoff at the Stout Site would travel in a south-southeasterly direction to enter the main stem of Rock Creek east of Country Club Manor.

The contaminated fill originated from the floodplain of the Romaine Creek Valley, which consists of eroded material from the hillslopes, a clay and chert gravel material with a silt rich surface soil. Thus, the fill would partly consist of a stoney, silty clay material.

Unique Site Characteristics

The Stout Site is located on an extremely steep slope, which will complicate any remedial activity.



AY6058 1.0 (Surface)
AQ2983 29.0 (0-6" deep) K7
AQ2982 10.0 (0-6" deep) K8
10 ppb
AQ2976 33.0 28.7 (0-6" deep) K11
AK4209 1.8 (Surface)
AQ2962 49.0 (0-6" deep) I8
AQ2958 150.0 (0-6" deep) H8
AQ2959 2.1 (0-6" deep) H7
AQ2960 48.0 (0-6" deep) H6
1 ppb
AQ2952 2.9 5.9 (0-6" deep) G7
AQ2951 5.7 (0-6" deep) G8
AQ2950 20.0 (0-6" deep) G9
AQ2947 20.0 (0-6" deep) F7
AY6043 1.0 (Surface)
AY6081 22.2 (10' deep)
AY6082 3.9 (15' deep)
AY6083 5.8 (20' deep)
AY6041 1.0 (Surface)
AY6072 1.0 (10" deep)
AY6073 1.0 (15' deep)
AY6074 1.0 (20' deep)
AY6025 1.0 (Vacuum dust)
AY6069 1.0 (10' deep)
AY6070 1.0 (15" deep)
AY6071 1.0 (20" deep)
AY6042 1.0 (12-18" deep)
AY6064 1.0 (5' deep)
AY6051 1.0 (Surface)
AY6065 1.0 (5' deep)
AY6028 1.0 (Surface)
AY6037 1.0 (Surface)
AQ2943 11.0 (0-6" deep) I5
AQ2942 36.0 (0-6" deep) H5
AY6057 1.0 (Surface)
AQ2938 6.2 (0-6" deep) I4
AQ2934 12.0 (0-6" deep) I3
AY6061 1.0 (Surface)
AQ2057 2.1 (0-6" deep) G6
AQ2944 2.4 (0-6" deep) F4
AQ2917 6.4 (0-6" deep) E4
AQ2929 8.2 (0-6" deep) F3
10 ppb
10 ppb
AQ2932
AQ2931
AQ2925
AQ2924
AQ2927
AY6045 1.0 (Surface)
AY6078 (10' deep)
AY6079 (15' deep)
AY6080 (20' deep)
AY6005 (Surface)
AY6047 1.5 4.4 (Surface)
AY6076 1.0 (15' deep)
1 ppb
AY6026 1.0 (Vacuum dust)
AQ2901 2.7 (0-6" deep) A1
1 ppb
AY6039 1.0 (Surface)
AY6066 1.0 (10' deep)
AY6067 1.0 (15' deep)
AY6068 1.0 (20' deep)

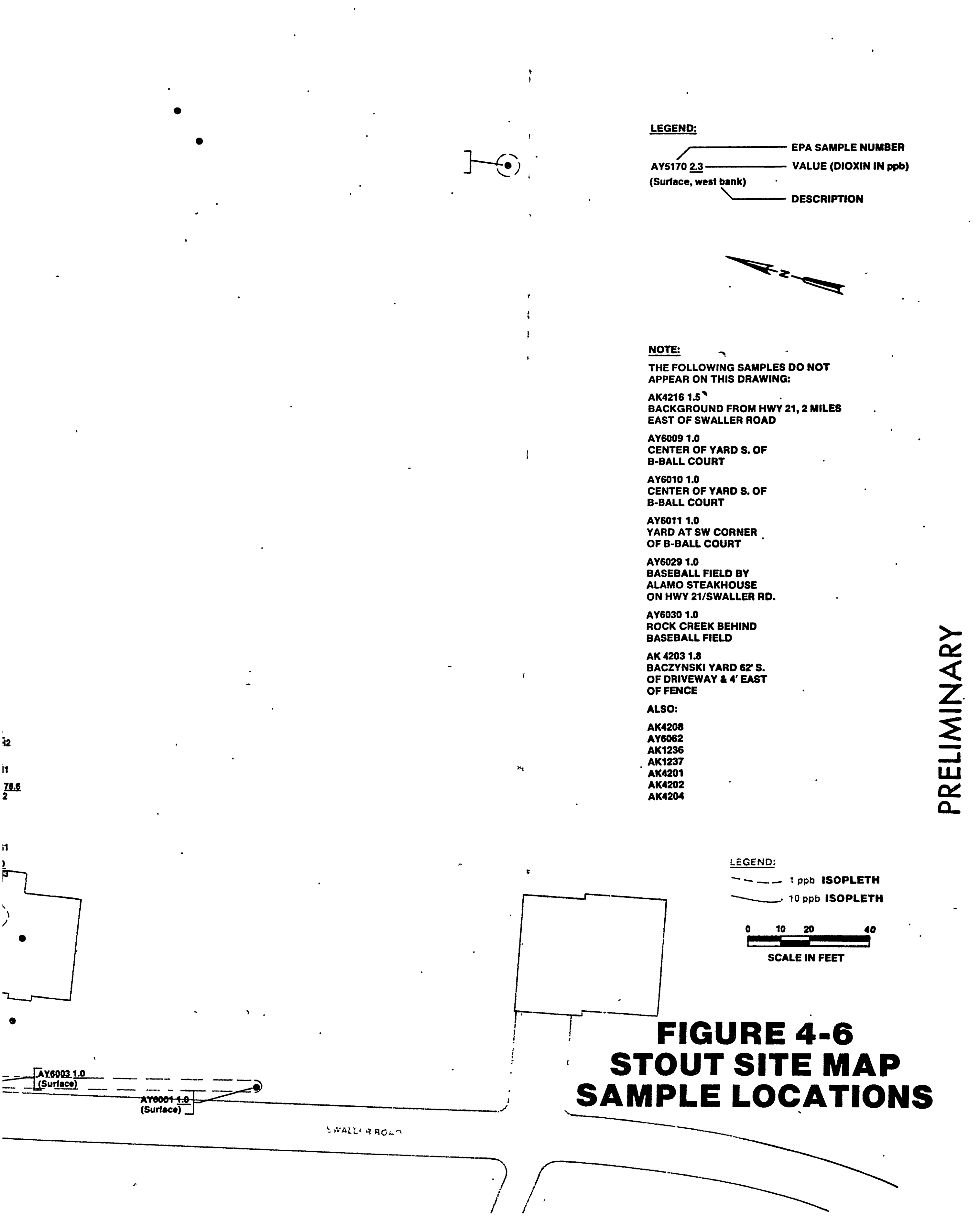


FIGURE 4-6
STOUT SITE MAP
SAMPLE LOCATIONS

ROMAINE CREEK

Location

Begins: NE 1/4, Sec. 29, T. 43 N., R. 5 E., 5th P.M.
Maxville Quadrangle
Jefferson County

The creek flows approximately 5 miles northeasterly to enter the Meramec River at the Jefferson County - St. Louis County boundary.

Accessibility

Romaine Creek Road and West Romaine Creek Road generally parallel the creek, with several crossings. The head of Romaine Creek can be entered from the Minker site. Romaine Creek Road is low type bituminous.

History Summary

The Bubbling Horse Ranch horse arena, sprayed with contaminated waste oil in 1971, was the origin of the contaminated soil in Romaine Creek. When the arena was excavated and the material moved to the Minker Site, the soil began to erode and move into Romaine Creek. Contamination of Romaine Creek has come primarily from the Minker Site, and to a lesser extent, possibly from the Ruth Sullins property and the Bubbling Springs Ranch horse arena. The Romaine Creek site along with the Minker and Stout sites is included on the National Priorities List. A State Superfund contract has been signed with the State for these three sites. The contract covers relocation and a feasibility study for the sites.

Site Description (see map)

The majority of contaminated stream sediment has been found within approximately one mile downstream of the Minker site, in the intermittent portion of the creek. 2,3,7,8-TCDD levels range up to 272 ppb, and generally decrease as the distance from the Minker site increases. Since the contaminated soil was transported into the creek by erosion, it generally does not extend outside of the creek banks. Contamination has been found down to two feet below the surface. Beyond one mile downstream of the Minker site, the 2,3,7,8-TCDD levels are near or less than 1 ppb. Contamination levels of 0.3 ppb and 0.79 ppb found downstream of the Bubbling Springs Ranch could have originated from either the horse arena or the Minker site. Contaminated soil is continuing to be moved during periods of rain. Due to the geology of the area, there is a potential for movement of soil particles in Romaine Creek into the subsurface and groundwater.

Geologic and Soils Description

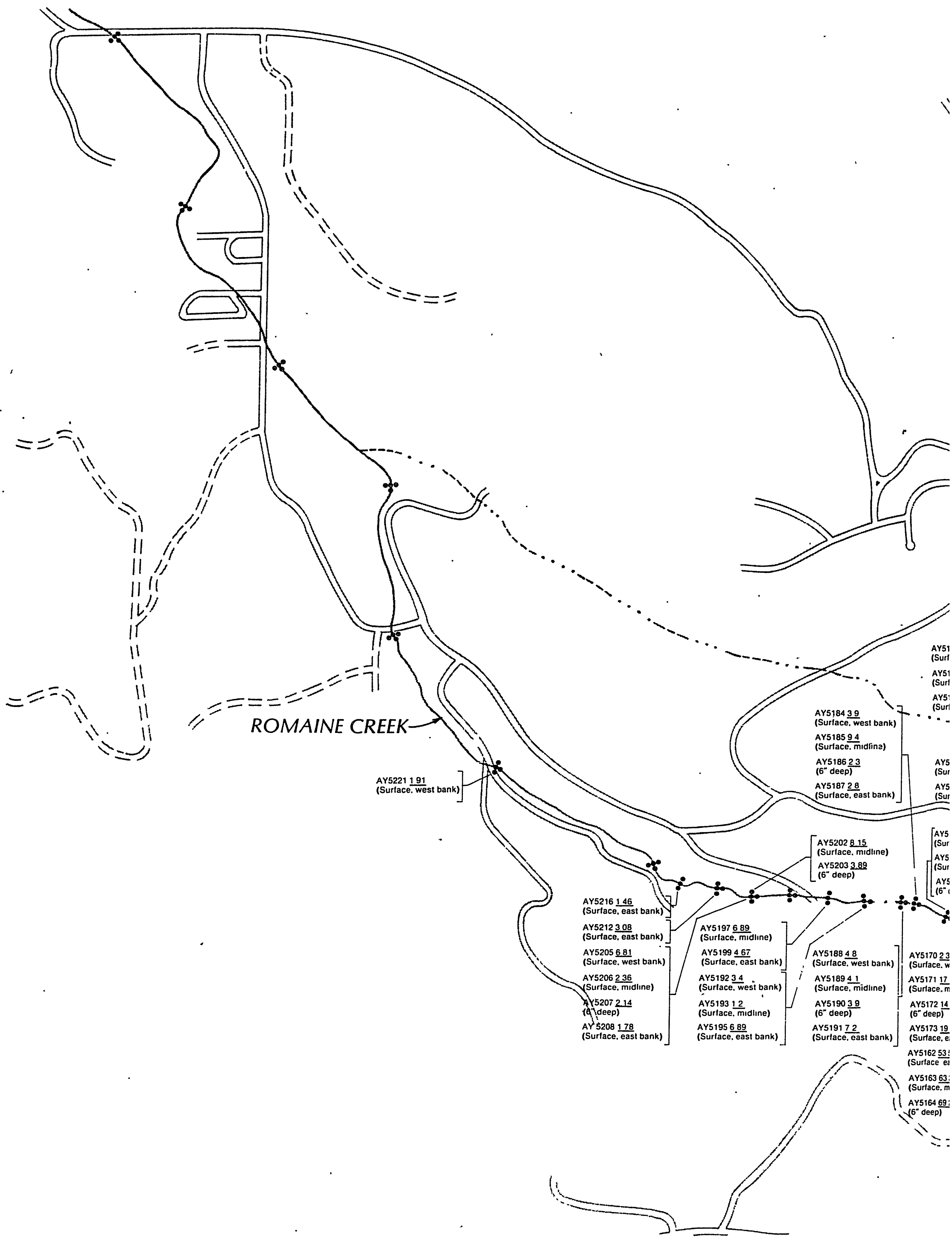
A highly permeable stoney clay residual soil exists in the upper Romaine Creek watershed, allowing movement of surface water into the subsurface probably including sediment transport 50 to 100 feet or more. The upper part of Romaine Creek, approximately one mile, is considered a losing stream. From the point of water flow, near the northwest corner of Sec. 21, T. 43 N., R. 5 E., a continuous and probably perennial flow would be expected all the way to the Meramec River.

The direction of flow of subsurface water lost into the upper watershed of Romaine Creek including the area of the Minker Residence is anticipated to be northeast. This water and possibly sediment would be expected to emerge as stream flow in the main stem of Romaine Creek or one of its tributaries. It is thought that Bubbling Springs would not receive this localized flow due to bedrock structure and lithologies. It is believed that groundwater recharge to Bubbling Springs is regional. A study currently being conducted by the U.S.G.S. and Missouri Division of Geology and Land Survey will further define the complex hyrology of the Romaine Creek Basin.

It appears that contaminants eroded from the horse arena at Bubbling Springs would not recharge groundwater, but would move into Romaine Creek and stay in the stream channel to its conjunction with the Meramec River.

Unique Site Characteristics

The contaminants in Romaine Creek are currently very mobile. They also pose a threat to water and aquatic life.



Sample Info
OVERALL

SITE
OVERALL

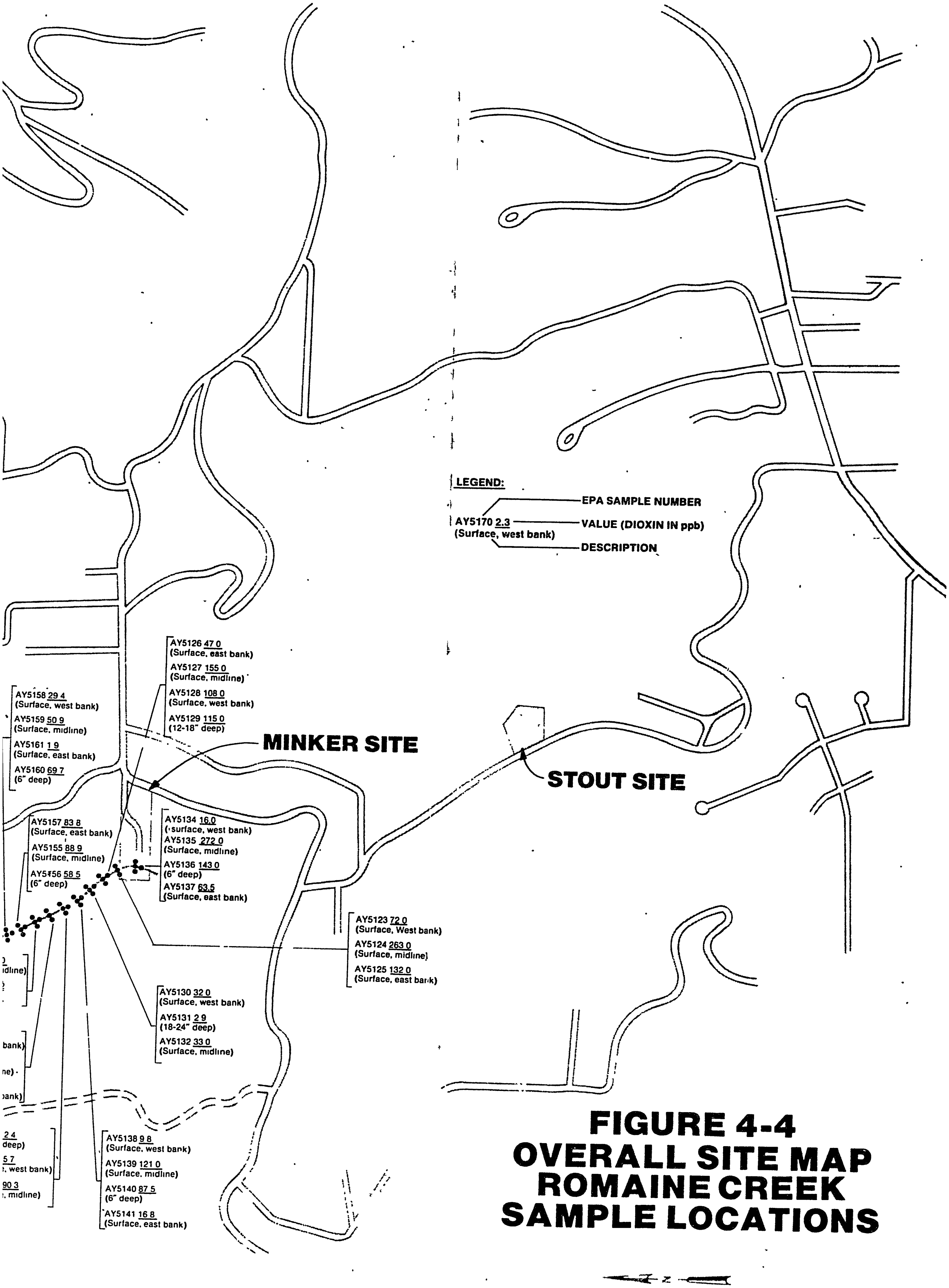
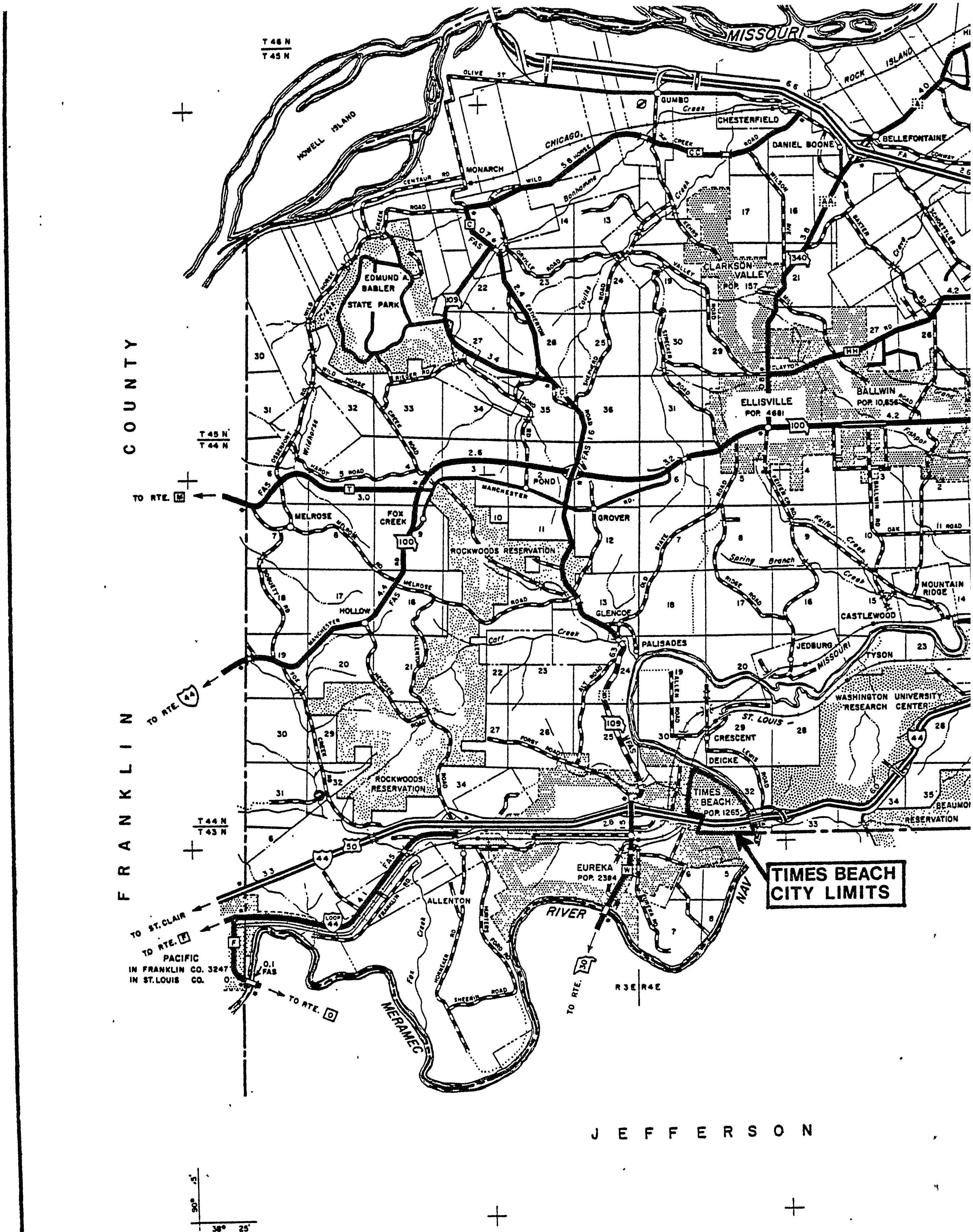


FIGURE 4-4
OVERALL SITE MAP
ROMAINE CREEK
SAMPLE LOCATIONS


MISSOURI
HOWELL ISLAND
T 46 N
T 45 N
GUMBO
CHESTERFIELD
DANIEL BOONE
BELLEFONTAINE
ROCK ISLAND
MONARCH
CHICAGO
EDMUND A. BABLER STATE PARK
CLARKSON VALLEY POP. 157
ELLISVILLE POP. 4681
BALLWIN POP. 10,656
T 45 N
T 44 N
POND
MANCHESTER
GROVER
MELROSE
FOX CREEK
ROCKWOODS RESERVATION
HOLLOW
GLENCOE
PALISADES
JEDBURG
TYSON
CASTLEWOOD
MOUNTAIN RIDGE
WASHINGTON UNIVERSITY RESEARCH CENTER
CRESCENT
DEICKE
TIMES BEACH POP. 1265
T 44 N
T 43 N
EUREKA POP. 2384
ALLENTON
RIVER
MERAMEC
PACIFIC
IN FRANKLIN CO. 3247
IN ST. LOUIS CO.
TO RTE. M
TO RTE. 44
TO ST. CLAIR
TO RTE. F
TO RTE. O
TO RTE. 30
R 3 E | R 4 E
TIMES BEACH
CITY LIMITS
FRANKLIN COUNTY
JEFFERSON

TIMES BEACH

Location

Legal Description: Floodplain of the Meramec River, principally W 1/2, Sec. 32, and E 1/2, E 1/2, Sec. 31, T.44 N., N., R. 4 E., 5th P.M.
Manchester Quadrangle
St. Louis County
Latitude: 38° 30' 33"
Longitude: 90° 36' 08"
Population 2,061

Accessibility

The City of Times Beach can be entered by any of three routes. Access is gained by exiting Interstate 44 onto the northern outer road from either east or west of the city. The third access point is from the south from Route W onto local roads.

History Summary

In June 1972, a city ordinance was passed to contract with a waste oil hauler to spray the roads for dust control. Apparently all of the gravel streets were oiled that summer twice and a third time where needed, as recalled by residents. In 1973, the roads were again sprayed by contract. The agreement was to have approximately ten miles of road oiled. Five additional streets had been paved so less oiling was done that year. EPA sampled the roads and right-of-ways in November and December 1982, and found 2,3,7,8-TCDD levels up to 127 ppb. In December 1982, the Meramec River flooded the town. EPA sampling in January 1983 following the flood showed that the contaminated soil remained quite immobile throughout the flooding. On February 22, 1983, the EPA Administrator announced a $33 million pledge from superfund to purchase the Times Beach property under a relocation plan to be developed and implemented by the Federal Emergency Management Agency (FEMA). EPA is planning to have a feasibility study conducted to determine the scope and costs of cleanup alternatives. The city is on the National Priorities List.

Site Description (see maps)

Times Beach is principally bounded by the Meramec River, Interstate 44, and the Burlington Northern Railroad tracks. Being in the 100-year floodplain, the area is relatively flat. The majority of the city's 28 miles of paved and gravel road, shoulders, and ditches are contaminated. Maximum levels of 2,3,7,8-TCDD are shown on the city map. Contamination has been found down to at least two feet below the surface. The City of Eureka, population 3,862 lies immediately to the south and west of Times Beach. None of Eureka's streets were oiled and no contamination has been found within the city. Results of all groundwater sampling in the area have been negative.

Geologic and Soils Description

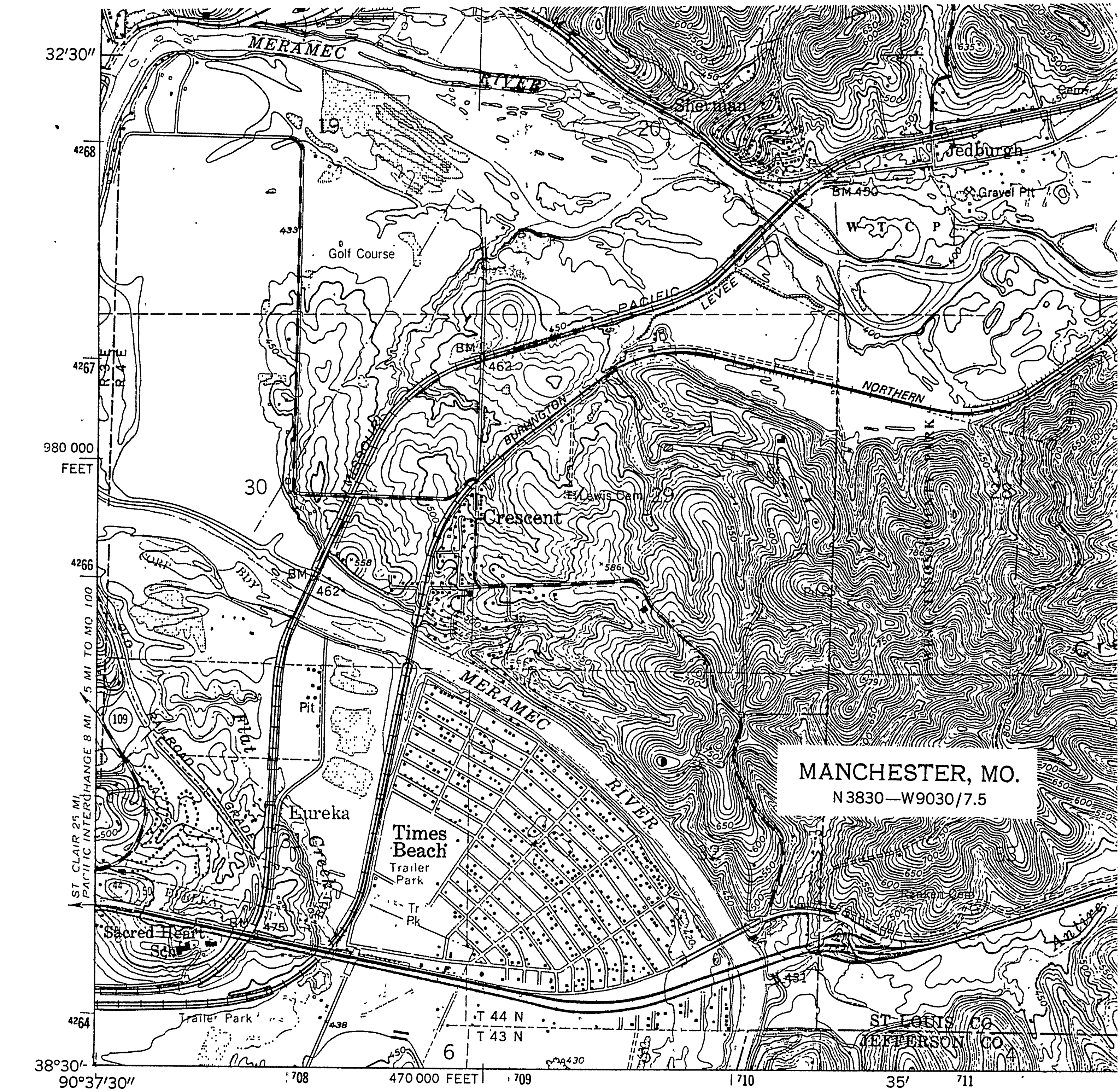
Times Beach is on an alluvial setting, underlain by alluvial silt to a depth of more than 5 feet. Below the alluvial silts; sand, gravel, and a mixture of silt, sand, and clay would be expected to a depth of from 40 to 50 feet where bedrock is encountered. The water table would be expected to be about at the Meramec River level, between 10 and 20 feet from the surface in most of the area.

The alluvial silt has a relatively low permeability and would be expected to be wet natured in that it does not readily or rapidly drain water. Due to this and the screening effect of the silt, it is not likely that soil particles contaminated with dioxin would move down into the water table.

It can be assumed that the contaminated material consists of road bed material plus native soil where the contamination has eroded into the ditches.

Unique Site Characteristics

The Times Beach site comprises the largest volume of contaminated material of all of the sites. Its location in the floodplain will require extra precautions for any remedial activity.



Mapped by the Army Map Service
Published for civil use by the Geological Survey

Control by USGS, USC&GS, and USCE

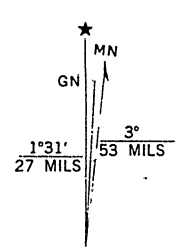
Topography from aerial photographs by photogrammetric methods
Aerial photographs taken 1952. Field check 1954

Polyconic projection. 1927 North American datum
10,000-foot grid based on Missouri coordinate system, east zone
1000-meter Universal Transverse Mercator grid ticks, zone 15, shown in blue

Dashed land lines indicate approximate locations

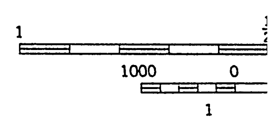
Unchecked elevations are shown in brown

To place on the predicted North American Datum 1983 move the projection lines 2 meters south and 10 meters east as shown by dashed corner ticks



UTM GRID AND 1982 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

There may be private inholdings within the boundaries of the National or State reservations shown on this map



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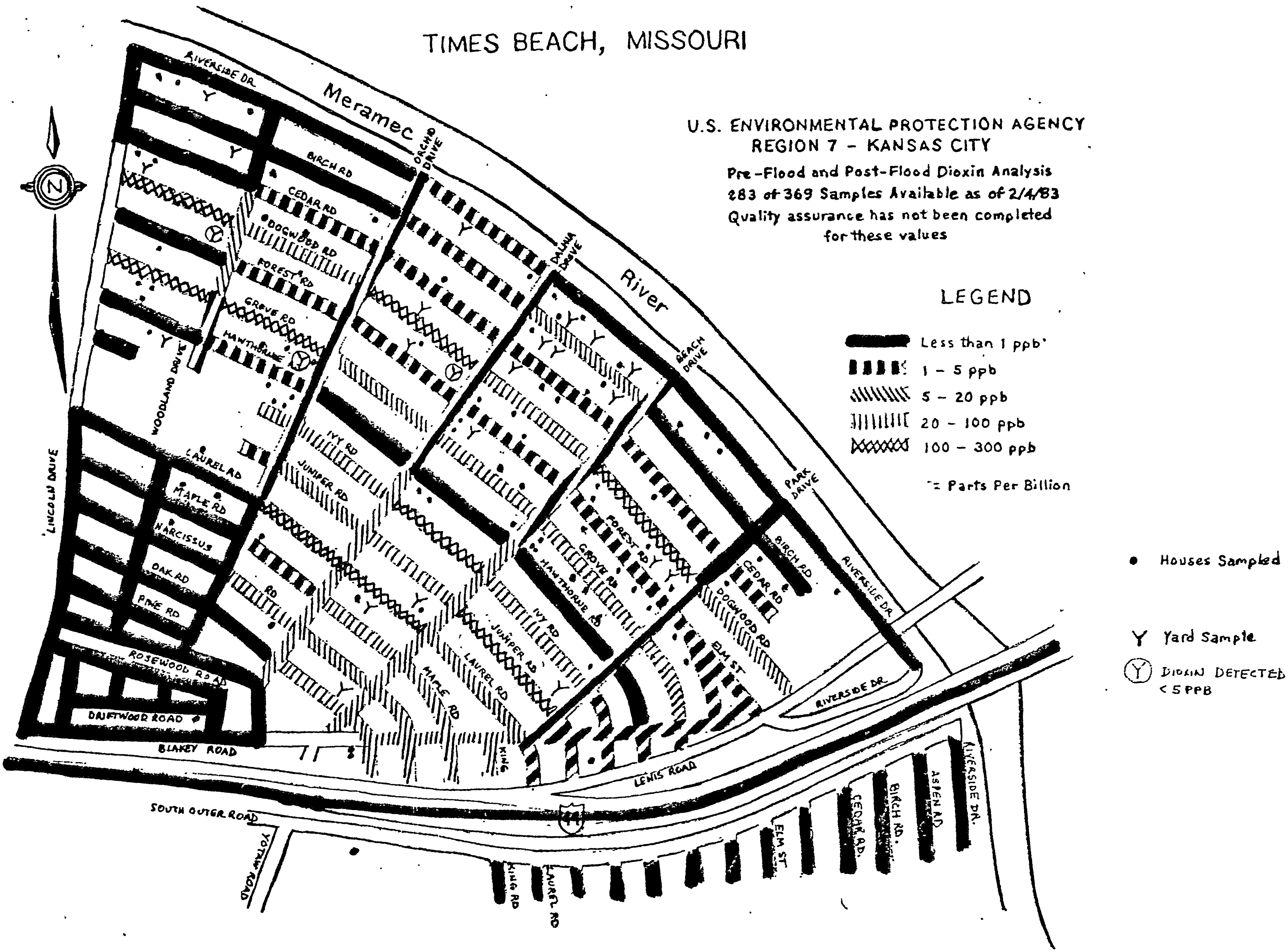
TIMES BEACH, MISSOURI
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 7 - KANSAS CITY
Pre-Flood and Post-Flood Dioxin Analysis
283 of 369 Samples Available as of 2/4/83
Quality assurance has not been completed
for these values
LEGEND
Less than 1 ppb*
1 - 5 ppb
5 - 20 ppb
20 - 100 ppb
100 - 300 ppb
* = Parts Per Billion
Houses Sampled
Yard Sample
Dioxin Detected
< 5 PPB
Meramec
River
RIVERSIDE DR
BIRCH RD
CEDAR RD
DOGWOOD RD
FOREST RD
GROVE RD
HAWTHORNE
ORCHARD DRIVE
DAKOTA DRIVE
BEACH DRIVE
PARK DRIVE
WOODLAND DRIVE
LINCOLN DRIVE
LAUREL RD
MAPLE RD
NARCISSUS
OAK RD
PINE RD
ROSEWOOD ROAD
DRIFTWOOD ROAD
BLAKEY ROAD
IVY RD
JUNIPER RD
MAPLE RD
LAUREL RD
JUNIPER RD
IVY RD
HAWTHORNE RD
GROVE RD
FOREST RD
BIRCH RD
CEDAR RD
DOGWOOD RD
ELM ST
RIVERSIDE DR
KING
LEWIS ROAD
SOUTH OUTER ROAD
YOTAW ROAD
44
KING RD
LAUREL RD
ELM ST
CEDAR RD.
BIRCH RD.
ASPEN RD
RIVERSIDE DR.

CHAPTER 2

SUMMARIES OF EXPERTS' PRESENTATIONS

In an effort to become better informed about the current medical and environmental issues surrounding dioxin, the Task Force has heard from a number of experts in the field of dioxin research. Following are summaries of these experts' speeches at the Task Force meetings.

William G. Dunagin, M.D.
Division of Dermatology M173
University of Missouri
Health Science Center

DIOXIN EFFECTS ON HEALTH SUMMARY

Many misleading statements have been made in the press about the health effects of dioxin. Consequently, the fear that many people in the general public have may be out of proportion to the real hazard. For example, the statement that dioxin is 180,000 times as toxic as cyanide has been repeated numerous times in the media. This is certainly not true for any species of mammal. The most sensitive mammal is the guinea pig where the single dose LD_{50} for dioxin is 250 times pure cyanide or 1000 times cyanide salts. These comparisons also assume that one is dealing with pure dioxin. Actually the dioxin in Missouri is in trace quantities expressed as parts per billion.

The single dose LD_{50} for monkeys is 50 micrograms per kilogram. Humans are probably in the same range (Dr. Neal has estimated the level as more than 100. Analogy with Yusho disease indicated the same range). Using this figure of 50 micrograms per kilo for humans, we can see that dioxin is about 10 times as toxic as cyanide.

Dioxin	50 ug/kg
HCN	500 ug/kg
Cyanide salts	2000 ug/kg
Cantharidin	300 ug/kg
Nicotine	600 ug/kg
Colchicine	300 ug/kg
Digitoxin	35 ug/kg

The last four chemicals are on the shelves of every pharmacy in Missouri. The toxicity of dioxin is not totally out of the range of many substances we are used to dealing with. Dermatologist commonly use a preparation that contains seven parts per thousand of cantharidin in order to kill warts.

Another point that is poorly understood by the general public is that dioxin must be absorbed into the body before it can produce any harmful effect. It does not release radation or vapors. Theoretically dioxin can be absorbed through the skin, intestinal tract, or lungs. Dermal absorption may have been important in 1971 when the waste oil containing dioxin was freshly sprayed on horse arenas. The situation today is different. The dioxin is attached to soil particles and is in much lower concentrations. The work of Poiger and Schlatter at the Swiss Federal Institute of Toxicology using soil from Seveso, Italy, suggests that only one percent or less of an applied dose of dioxin in a soil-water mixture is likely to be absorbed through the skin at concentrations below one part per million. This finding is not at all unusual. The percutaneous absorption of most aromatic hydrocarbons varies greatly depending on the vehicle. The amount absorbed topically is insignificant, and others have shown that inhalation of dust containing one part per billion (the level reported by EPA via newspaper accounts as the highest levels in dust from homes in Times Beach is insignificant). So for practical purposes, ingestion of dioxin is the only way that people in Missouri could get toxic effects, today.

The FDA has set levels of 50 parts per trillion of dioxin for ingesting fish on a one time basis or 25 if fish are eaten on several occasions. A 3 1/2 ounce serving of fish would weigh 100 grams. The equivalent amount of soil containing 1 part per billion of dioxin would be 5 grams. It is unlikely that a competent person would ingest more than this without being aware.

The main objective effects of dioxin are chloracne, porphyria cutanea tarda, peripheral nerve damage, and nerve conduction abnormalities (no objective evidence of organic brain damage). Other effects which have occured rarely in humans, probably only at high doses, and are known mainly from animal experiments, are hepatic necrosis, T cell depression and bleeding tendency. Other conditions such as increased triglycerides, have been reported but it is unclear if they are signigicantly increased compared to a suitable control population.

The importance of chloracne is that it seems to be the most sensitive indicator of dioxin exposure. In some examples of low level exposure to dioxin such as Seveso, Italy, and Bolsover, England, it was the only objective finding. In examples of industrial accidents where there was high level exposure, 80-90% of workers who had some of the more serious effects of dioxin also had chloracne. Chloracne was present in 90% of patients with Yusho, a disease caused by chemicals (dibenzofurans) which are very closely related to dioxin.

So for any one individual, chloracne does not have to be present. However, for a large group of people, it is very unlikely that every person would be an exception to the rule. The preliminary reports of the CDC examination of 186 residents of Times Beach were that no cases of chloracne were found. No one from any other site in Missouri today has chloracne to my knowledge. This is very good news, and indicates that the other direct toxicities of dioxin are unlikely.

Another misconception that many people have is that dioxin may cause serious toxicity a long time in the future. Actually, the principle of a long latency period applies only to cancer. Someone whose liver is in good condition today, and who receives no further dioxin, is not going to suddenly come down with massive liver necrosis or chloracne several years from now.

The question of cancer is very complicated. Basically, the doses of dioxin which have caused cancer in laboratory animals are higher than the doses that produce toxicity. This is not the usual concept that the public has of a silent killer. Dioxin is not a carcinogen in the strict sense of the term. It does not alter the structure of DNA. However, it may be a promoter or cocarcinogen. The concept that any amount at all of carcinogen is bad because lower and lower doses may still cause cancer in a lower and lower percentage of people probably does not apply in the same sense for a promoter.

Amoung humans who have had significant exposure to dioxin after industrial accidents (Nitro, West Virginia, Ludwigshafen, Germany, and Czeckoslovakia) there does not appear to be an increased incidence of cancer, overall. Some people have pointed to the date from Nitro as showing increased lymphoma-leukemia. This is not statistically significant. The same data show that cancer of the stomach and colon were less than expected, in fact the statistics would be better for saying that dioxin prevented cancer of the stomach and colon. Actually neither statement is true, but it illustrates how some people can take bits and pieces of data out of context from epidemiologic studies.

The only types of cancer which may be increased above normal levels are a diverse group of rare tumors called soft tissue sarcomas. Even this is not certain, and more work needs to be done.

David Stalling, Ph.D.
Chief Chemist
Columbia National Fisheries
Research Laboratory
U.S. Fish and Wildlife Service

DIOXINS AND DIBENZOFURANS IN THE AQUATIC ENVIRONMENT: RESIDUES IN FISH AND ENVIRONMENTAL FATE

Polychlorinated - dibenzo-p-dioxins (PCDDs) and -dibenzofurans (PCDFs) have been measured in fish and other aquatic samples at concentrations from 1 pg/g to in excess of 1 ug/g. In order to measure these compounds at levels of 1 pg/g by GC/MS techniques, they must be separated from interfering substances (PCBs, polychlorinated-hydroxybiphenyls, -phenoxyphenols, and -diphenyl ethers) and concentrated. We employ column extraction and two sequentially linked chromatographic adsorbents to enrich PCDFs and PCDDs from other co-extractives. Fish from a variety of lakes and rivers were analyzed for PCDDs and PCDFs. PCDF residues were more complex thatn PCDD residues, and were dominated by isomers having 2,3,7,8 - chlorine substitution.

PCDF residues were present in samples from all of the Great Lakes and exceeded 100 pg/g in fish from Lakes Ontario, Huron, Michigan, and Saginaw Bay. We measured the ratio of PCB to PCDF concentrations in fish from the Great Lakes to be approximately 100,000 to 1. A composite sample of fish from the Tittabawassee River (Michigan) contained 290 pg/g of PCDFs and 223 pg/g of PCDDs. The PCDF concentrations in fish from Lake Siskiwit (on Isle Royale, Lake Superior) were determined to be 15 pg/g Fish from Lakes Huron and

Ontario, the Tittabawasse River and Saginaw Bay contained the highest concentrations of 2,3,7,8-TCDD. In the Housatonic and Hudson, the composition of PCDD and PCDF residues in sediments differed radically from residues in fish. The residue profiles observed were similar in that the higher congener groups (hepta and octachloro) predominated in contrast to residue profiles in fish where tetra- and pentachloro congeners were dominant.

Contamination from PCDFs is related closely to PCBs. PCBs contain part-per-million concetrations of PCDFs and PCBs can be converted to PCDFs by heating PCBs to temperatures of 300-500 ^{o}C in the presence of air or by low temperature burning of materials containing PCBs. TCDD is most frequently associated with chlorophenols and can be produced in high yeilds when 2,4,5-trichlorophenol is heated or burned. Distillation residues or manufacturing wastes from the production of materials made from 2,4,5-trichlorophenol have been involved with most of the TCDD related pollution problems.

Assessment of the impacts and fate of these chemicals in aquatic ecosystems is difficult because only a limited amount of chronic toxcity data is available for aquatic organisms. Exposure of fish fry to low part-per-trillion concentrations has been reported to cause decreased growth and survival. Delayed mortality, 10-15 days after exposure, has been reported.

Data reported from outdoor pond studies provide some insight into the bioavailability and distribution of TCDD in aquatic ecosystems. In one recent study investigating the fate of TCDD in small outdoor pools, a major portion of added TCDD was concentrated in aquatic plants, fish and the hydrosoil-water column interface. Bioconcentration of TCDD by fish in model ecosystem studies was reported to be approximately 6,000 times the water concentration.

No data for TCDF toxicity to aquatic organisms or PCDF bioconcentration factors from water exposure have been reported. However, based on the ratios of PCDFs to PCBs detected in fish, bioconcentration of PCDFs by fish appears to be comparable to PCBs. Fish from contaminated areas could be important as dietary sources of PCDFs and TCDD in humans. The Food and Drug Administration has recommended that fish having residues of TCDD in the range 25-50 parts per trillion not be consumed more frequently than once weekly and fish having more than 50 parts-per-trillion TCDD not be consumed.

The data obtained from analysis of fish and sediments in river systems studies thus far, suggests that TCDD and TCDF are concentrated in fish and other organisms, while the more highly chlorinated Cl_7-, andCl_8-isomers are concentrated in sediment. This altered distribution suggests that TCDD can not be considered to be unavailable to organisms when admixed with soil that is translocated into streams.

Alvin L. Young, Major USAF, Ph.D.
Special Assistant for
Environmental Sciences (10A7B)
Veterans Administration

PART I

ENVIRONMENTAL FATE OF TCDD -- CONCLUSION FROM THREE LONG-TERM FIELD STUDIES

The toxin 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is known to occur as both a contaminant of products made from trichlorophenols and as a by-product from low temperature incineration of wastes containing chlorinated precursors. The magnitude of environmental contamination by the 2,3,7,8-TCDD isomer is currently the subject of intense debate. Although a number of TCDD sources has been identified, environmental monitoring programs for TCDD have generally been unsuccessful in documenting contamination. However, with continued development of sophisticated instrumentation for detecting TCDD in picogram quantities (parts per trillion, ppt) and with renewed interest in monitoring improper disposal of hazardous wastes, additional data on the distribution of TCDD in the environment are being obtained. This paper reviews the environmental data generated from three long-term field studies conducted by the United States Air Force in five distinctly different geographic locations in the United States.

Persistence data on TCDD were obtained from field plots treated in 1972 with sub-surface applications of massive quantities of the herbicides 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) in soils of Northwestern Florida, Western Kansas and Northwestern Utah. The fate of TCDD in biological systems was extensively studied in organisms that inhabited a unique 3.0 km^2 military test area in Northwestern Florida that was aerially-sprayed during the perios 1962 to 1970 with 73,000 kg 2,4,5-T containing 2.8 kg TCDD. The movement of TCDD in an aquatic exosystem has been extensively studied in an area adjacent to storage sites (Gulfport, Mississippi, and Johnston Island, Pacific Ocean) where more than 8.4 million L of surplus phenoxy herbicide had been maintained for more than six years. Thus, these studies have provided data on the persistence, movement, bioaccumulation and bioavailability of TCDD in the environment.

Soil Incorporation/Biodegradation Studies: One potential method proposed for the disposal of TCDD-contaminated phenoxy herbicides was subsurface injection or soil incorporation of the herbicide at massive concentrations. The premise for such studies was that high concentrations of the herbicides and TCDD would be degraded to innocuous products by the combined action of soil microorganisms and soil hydrolysis. In order to field test this concept, biodegradation plots were established in three climatically different areas of the United States; Northwest Florida (Elgin Air Force Base), Western Kansas (Garden City), and Northwestern Utah (Air Force Logistics Command Test Range Complex). The Utah site had alkaline soil and a mean annual rainfall of 15 cm, while the Kansas and Florida sites had acidic soils and 40 and 150 cm of annual rainfall, respectively.

Although the method of application was designed to simulate subsurface application of the herbicides and TCDD, the actual concentration of the chemicals varied significantly between locations. The Utah site received concentrations of herbicide exceeding 30,000 ppm (and 140 ppb TCDD) while the

Kansas site had soil concentrations of 2,000 ppm herbicide and 280 ppt TCDD. The TCDD was extracted from soil by using a 1:1 cold solution of hexane and acetone, followed by an acid wash. Confirmation of the compound was done by gas chromatography-mass spectrometry. The results from monitoring the fate of TCDD in these plots indicated that the TCDD rapidly "disappeared" so that less than 15 percent was recovered two years later. Because the plots showed similar patterns in TCDD disappearance, it was suggested that the analytical method was measuring only "free" TCDD and not "total" TCDD. Indeed, examination of archived soil samples using exhaustive extraction techniques revealed that more than 80 percent of the applied TCDD could be recovered. The conclusion of the study was that TCDD underwent a "binding" with soil over time and that a simple extraction technique was insufficient to recover the total TCDD. These data are illustrated in Figure 1.

Fate of TCDD in an Ecosystem: Field studies of TCDD were conducted during 1973-1979 on a unique 3.0 km^2 military test area (Test Area C-52A, Eglin Air Force Base, Florida) that was aerially-sprayed with 73,000 kg of 2,4,5-T during the period 1962-1970. Analysis of archived samples of the formulations indicated that approximately 2.8 kg of TCDD were applied as a contaminant of the herbicide. However, 2.6 kg were applied to a 37 ha test grid (Grid I) from June 1962 through July 1964. Levels of <10 to 1,500 ppt could be found in the top 15 cm of soil 14 years after the last application of herbicide on this site. Nevertheless, analysis of 61 soil samples suggested that less than one percent of the TCDD remained on the test area.

Over the years of observation, approximately 341 species of organisms have been observed and identified as associated with that test area. To date, over 300 biological samples (plant and animals) have been analyzed for TCDD. TCDD residues have been found in a wide spectrum of animals collected from the test area. Approximately one-third (21) of the different species examined for TCDD residue have been positive. In general, the levels of TCDD in the organisms appeared to be close to the mean levels of TCDD found in soils.

Field toxicological investigations were conducted during 1973-1978 on populations of the beachmouse, Peromyscus polionotus. Liver tissue from 36 individual beachmice inhabiting the test site contained 300 to 2,900 ppt TCDD. Although bioconcentration factors (mean liver concentrations divided by mean soil concentrations) ranged from 6 for females to 18 for males a bioavailability mechanism for TCDD in soil may have been operative (see figure 2). Whole body analysis for fetuses from test area females indicated apparent placental transport of TCDD. Histopathological examinations were performed on 255 adult or fetal beachmice from the test area and control area. Mircoscopic examinations were performed on 18 different tissues from each animal. The tissues were first examined on a blind study basis and then re-examined on a control versus test basis which demonstrated that the test and control mice could not be distinguished histopathologically. The mean number of fetuses per observed pregnancy was 3.1 and 3.4 for the test area and control area, respectively. A two-factor (treatment and year) disproportional analysis of covariance of organ weights revealed that liver weights for pregnant beachmice from the test area were significantly heavier ($P<.01$) than liver weights of pregnant females from the control area, and these differences were consistent over the 5 years of observation. These studies suggested that long-term, low-level exposure to TCDD under field conditions has had minimal effect upon the health and reproduction of the beachmice.

TCDD in Herbicide Storage Sites: During the summer of 1977 the United States Air Force disposed of 8.4 million L of TCDD-contaminated phenoxy herbicide by high temperature incineration at sea. This operation, Project

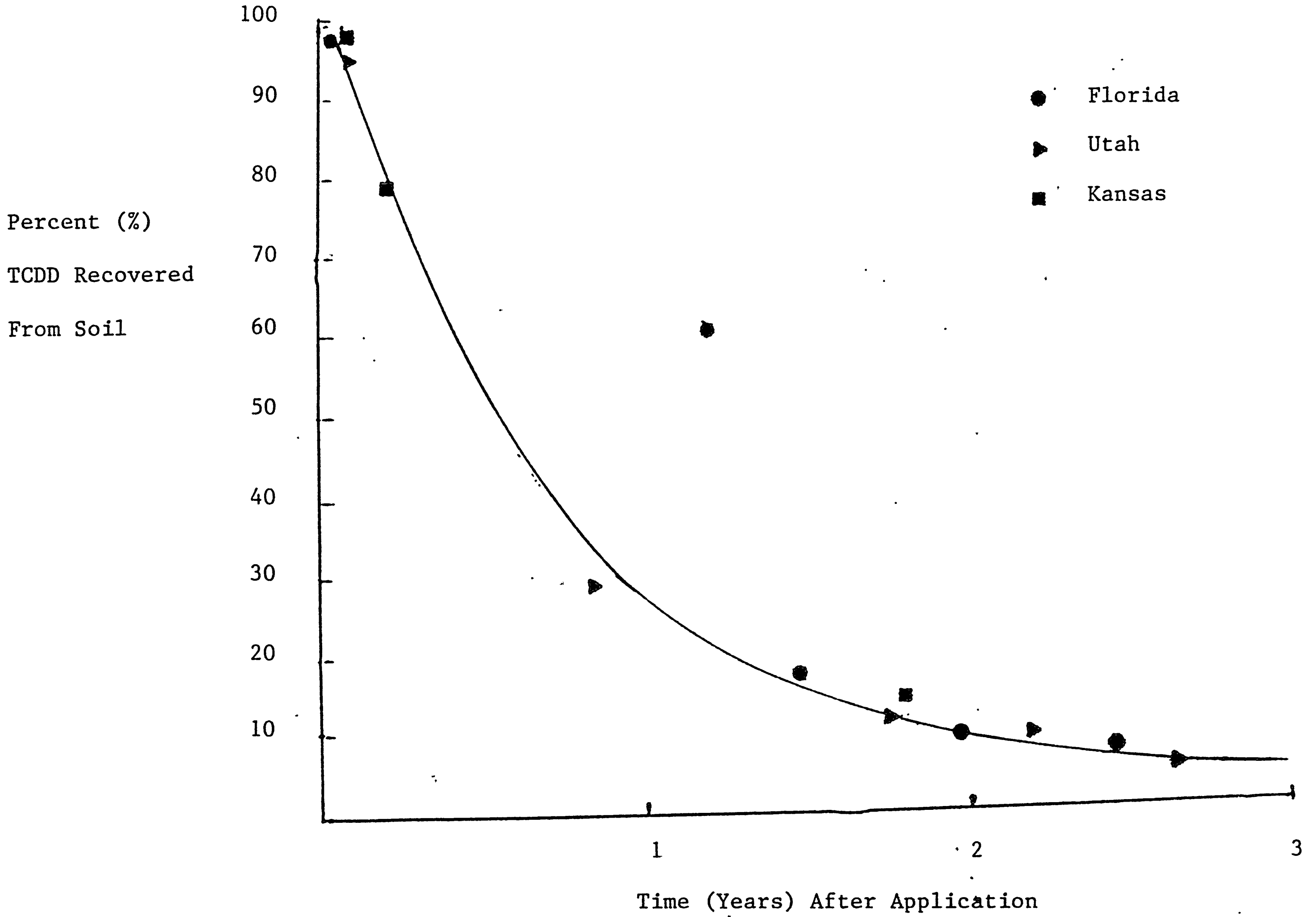

Figure 1. Recovery of 2,3,7,8-TCDD (percent) from three geographically distinct field sites at selected sampling times (years) following soil incorporation of contaminated phenoxy herbicides . [Subsequent re-analysis of soil samples following exhaustive extraction resulted in recovery of more than 80 percent of the original (incorporated) TCDD.]

BIOAVAILABILITY OF TCDD

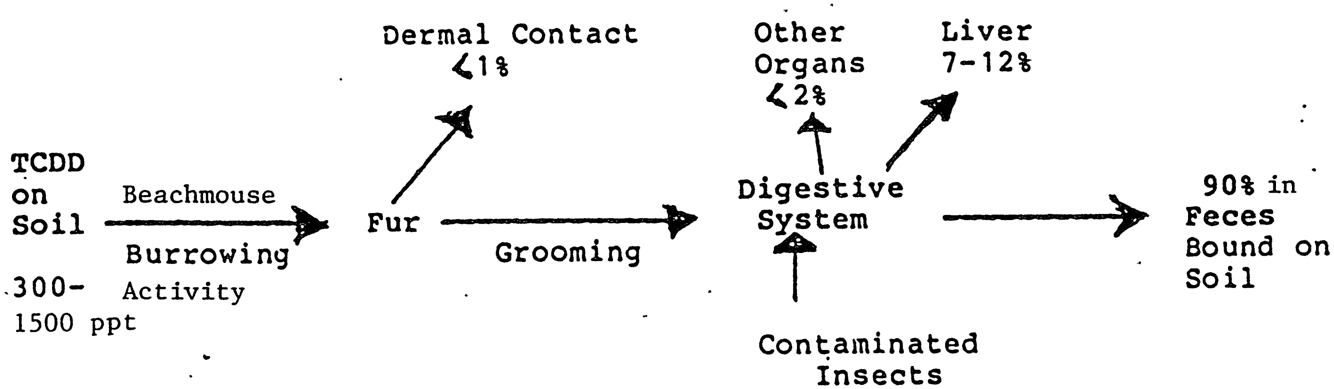

Figure 2. Scheme showing routes of TCDD contamination of the Beachmouse, Peromyscus polionotus, and the impact of bioavailability of TCDD in soil on exposure. Data are from environmental fate studies of TCDD on Test Area C-52A, Eglin AFB, Florida, 1973-1979.

PACER HO, was accomplished under the very stringent criteria set forth in an United States Environmental Protection Agency (EPA) ocean dumping permit. Among the numerous conditions of this EPA-approved disposal operation was the requirement for the USAF to conduct an extensive storage site reclamation and environmental monitoring program. Details of the proposed site monitoring program were prepared and approved prior to the disposal of the herbicide. The plan recommended that soil samples from the storage areas at both the Naval Construction Battation Center (NCBC), Gulfport, Mississippi and Johnston Island, Pacific Ocean, be collected and analyzed for herbicide and TCDD after the completion of transfer operations. These analyses were to aid in the establishment of a schedule for future monitoring. The site monitoring program would be flexible to requirements generated by construction of any facility on the storage areas and would be concluded upon mutual agreement of all agencies involved. This, the objectives of a site monitoring program were:

1. To determine the magnitude of herbicide and TCDD contamination on the storage areas.

2. To determine the soil persistence of the two phenoxy herbicides (2,4-D and 2,4,5-T) contained in the formulation and the TCDD contaminant.

3. To monitor for any movement of TCDD residue from the sites into adjacent water, sediments and biological organisms.

4. To recommend techniques for managing the storage areas with the ultimate goal of returning the areas to full beneficial unrestricted use.

In July 1977, a preliminary sampling study was initiated. This consisted of assessing the heterogenity of the soils on the sites and the heterogenity of the herbicide concentrations. Twelve sites were selected for sampling at each location; six were in areas of obvious spills and six in areas that showed no spill. Not only were the spills discernible by sight but also by smell. The results from this preliminary study indicated that significant concentrations of herbicides, phenols and TCDD were detected in soils from spill sites. Variations in concentrations and in the ratio of acids to esters suggested that the spills were from different time periods. Accordingly, a more extensive protocol was proposed for future sampling.

The protocol recommended that the sites selected within the two storage areas for monitoring of residue be determined by whether a spill had occured or not occurred at that specific location. The basis for determining a spill was whether a herbicide stain was discernible (heavy, light, absent) and whether a herbicide odor was detectible (strong, mild, absent). Thus, within the storage area numerous locations were found that had a heavy stain and strong odor (presumably representing a recent spill); a light stain and milk odor (presumably representing an older spill); and no stain and no odor (presumably representing an uncontaminated area). Fourteen replication of each treatment were then randomly selected to represent the storage area (thus a total of 42 permanently marked sampling locations at both NCBC and Johnston Island). Twelve of these locations had been tentatively located and marked in July 1977 with the remaining 30 locations and marked in January 1978 with sampling being conducted on these dates, as well in November 1978. In collecting the soil samples, a 8 cm square was marked 15 cm away from the site marker pin. At each sampling time soil was taken from a different "point of the compass" with

reference to the marker pin to insure a fresh and undisturbed profile. At the designated site a 8x8x8 cm cube of soil was removed with a ceramic spatula which was rinsed with acetone between uses to prevent carry-over of residue and mircoorganisms. Wherever possible, sediment samples were collected from the drainage areas in a similar manner. Biological samples were collected periodically in these drainage systems at varying distances from the storage sites. Residue studies of areas on the Naval Construction Battalion Center and Johnston Island resulted in the following conclusions:

1. Approximately 1 ha of the 5 ha areas were significantly contaminated with phenoxy herbicides and the associated dioxin (2,3,7,8-TCDD).

2. Levels of 2,4-D and 2,4,5-T herbicides in selected samples from the top 8 cm of soil profile were greater than 100,000 ppm in 1977, but rapidly decreased to one-third that level within 2 years.

3. Levels of TCDD exceeded 0.5 ppm in the soils of many spill sites and have shown trends to decrease over the 3 years of observations.

4. No accurate estimate of TCDD persistence is possible from these studies.

5. Soil penetration of the herbicides was low while soil penetration of TCDD was very low but measurable.

6. Soil sterilization did not occur as a result of herbicide or TCDD contamination, but rather poliferation of certain microflora occurred under high levels of residue.

7. Aquatic organisms found in the drainage system of the storage site at NCBC were significantly contaminated with TCDD (as high as 8 ppb TCDD). The level of TCDD in the organisms and associated sediment decreased rapidly with distance from the site so that samples collected at a distance of 2 km had low ppt levels of TCDD.

8. The principle recommendation for present management of the 5 ha areas at the Naval Construction Battalion Center and Johnston Island is that the areas be left undisturbed permitting the continuation of "natural" degradation of the herbicides and TCDD. Specific recommendations to prevent further movement of contaminated soil from the area included both limiting access to the storage areas and preventing water and wind erosion by stabilizing any potential sites for erosion.

PART II

DIOXIN IN BODY FAT AND HEALTH STATUS: A FEASIBILITY STUDY

Since 1978 there has been mounting concern over human exposure to 2,3,7,8-TCDD. Much of this concern has been expressed by veterans of the Vietnam war who believe that they were exposed to the TCDD-contaminated herbicide, 2,4,5-T, an ingredient of Agent Orange, the major defoliant used by the United States Armed Forces in Vietnam.

During a 5-year period from 1965 to 1970, the U.S. Air Force applied more than 40 million liters of Agent Orange containing more than 92 kg TCDD in South

Vietnam. Some two million American military personnel served 1-year tours during the same period. Many veterans of that era have reported medical problems that they ascribe to exposure to Agent Orange. Their complaints have ranged from tingling in the extremities to rare forms of cancer. Some veterans have fathered children with birth defects and have suggested that the TCDD is the cause. Accordingly, the Veterans Administration (VA) has initiated extensive health studies of veterans exposed by Agent Orange and its dioxin contaminant during the Vietnam Conflict.

Since TCDD is known to accumulate preferentially in the adipose tissue of certain species of laboratory animals, it was suggested, early in the history of the Agent Orange issue, that the analysis of human fat for TCDD might provide a way to determine earlier Agent Orange exposure. A relation between the presence of this substance health problems had also been suggested. Although methods for TCDD analysis have imporved in recent years, no such study had been carried out in humans with known exposure to herbicides containing this toxic contaminant. Consequently the VA embarked on a small feasibility study to test the methodology and to determine whether conclusions might be drawn regarding the significance of the results. The study was carried out in three groups of adult males as follows:

(1) Twenty Vietnam veterans all but one of whom claimed health problems related to Agent Orange exposure and who volunteered for the fat biopsy.

(2) Three U.S. Air Force officers with known heavy and relatively recent exposure in connection with herbicide disposal operations but who did not serve in Vietnam.

(3) Ten veterans with no service in Vietnam and no known exposure to herbicides who were undergoing elective abdominal surgery and who volunteered to serve as controls.

Methods: The prodedure called for the removal of 10-30 grams of subcutaneous adipose tissue from the abdominal wall. This was accomplished surgically under local anesthesia. Precautions were taken before, during and after the procedure to avoid contamination by products, e.g., hexachlorophene, that could contain TCDD. Specimens were collected in glass containers previously rinsed with acetone and dried before use. All tissues were refrigerated during shipment to the assay laboratory. Each of the volunteers had a medical history, physical examination, and routine clinical chemistry. The details of military service in Vietnam from the volunteer's report and his service record were examined to evaluate his potential exposure to military herbicides using the dates, location and nature of his service. From these a rough estimate of the likelihood of exposure to TCDD was made without knowledge of the assay results.

The extraction and assay of all samples for TCDD were conducted at the University of Nebraska, Midwest Center for Mass Spectrometry, Lincoln, Nebraska. Approximately 5 to 10 grams of tissue were used, when available, for each analysis. A known amount, generally 2 ng, of internal standard (either

^{37}C-2,3,7,8-TCDD or ^{13}C-2,3,7,8-TCDD) was added to the adipose tissue. The sample was digested in alcoholic potassium hydroxide followed by extraction with hexane to remove TCDD. The hexane extract was washed with concentrated sulfuric acid, neutralized, dried and concentrated. The final stage of preparation involved the use of three short-column liquid chromatography steps (silica gel, alumina and Florisel). Gas chromatography/high resolution mass spectrometry was employed for quantifation of 2,3,7,8-TCDD and coeluting isomers. Signal profiles were obtained at a mass resolution of 10,000 for m/z 321.8936, the most abundant molecular ion for TCDD, and for the internal standard mass by signal averaging for approximately 100 sec. commencing with the appearance of the co-eluting internal standard 2,3,7,8-TCDD.

Extracts which contained materials giving signals greater than 2.5 times noise at the exact mass of TCDD (i.e. 321.8936 \ 0.0020) over the integration period discussed above were reanalyzed. For the second analysis, signal profiles of m/z 321.8936 and m/z 319.8965 were monitored over the elution period of 2,3,7,8-TCDD (determined by injection of standard solutions). A positive detection was reported if signals were observed above the detection limit (2.5 times noise) and if their intensity ration was 1.0:0.78 + 0.10, which is consistent with the presence of four chlorine atoms in the molecule. Samples meeting all criteria except the correct isotope intensity ration have been considered to contain "not detectable" levels of TCDD. For these samples, it was judged that the presence of TCDD is not disproved by the observation of an incorrect isotope ration at these low concentrations; rather, the presence of TCDD is not confirmed.

Results: Of the twenty veterans who served in Vietnam, seven had no detectible TCDD with the limit of detection at 2 to 6 part per trillion (ppt). Another two had detectible material that could not be validated as TCDD and the results for one was considered equivocal because the measured value was only questionable above the detection limit. Five of the ten remaining Vietnam veterans had TCDD in amounts from 5 ppt to 7 ppt. Three Vietnam veterans had TCDD in the amounts from 9 ppt to 13 ppt. One individual had 63 and 99 ppt (average = 81 ppt) and another had 23 and 35 ppt (average = 29 ppt).

Of the ten control ("unexposed") veternas, four had TCDD indentified in their fat (6,7,7 and 14 ppt). Two other veterans had values low enough to be considered equivocal and in three instances the detected material was not validated as TCDD. The remaining veteran had no detectible TCDD.

One of the three Air Force officers with known exposure had no identified TCDD in his fat. The unidentified substance in his case and the TCDD measured in the other two officers was never more than 3 ppt above the limit of detection.

The clinical data were reviewed, seeking correlations between complaints or diagnoses and the assay results. Within the group of twenty Vietnam veterans, seven of them reported some health problems beginning in or during a tour of duty in Vietnam. No two, however, reported the same symptoms. The remaining thirteen veterans reported no illness in Vietnam although only one reported good health at all times. Among the nineteen veterans with current medical complaints, symptoms and diagnoses varied widely without any common pattern. Five had mental problems ranging from nervousness to schizophrenia and three had experienced difficulties of reporduction, namely, spontaneous abortions by the wives of two and congenital heart disease in the sone of a third.

Four of the seven veterans who reported difficulties while in Vietnam had no TCDD detected. The five veterans with mental problems included three without detectible TCDD and three whose assays results were 5 to 7 ppt. One of three veterans reporting reproductive problems had no detected TCDD, one had doubtful level and one had 7 ppt. Detectible TCDD in the body fat could not be correlated with clinical chemistry findings. Similar results applied to the controls i.e., veterans who did not serve in Vietnam.

The highest values for TCDD in adipose were found in two Vietnam veterans. Both men had military records substantiating duties that involved the use of TCDD-contaminated herbicides in Vietnam. Other individuals, however, who claimed extensive handling of herbicide in base perimeter operations had little or no TCDD in their adipose.

Discussion: TCDD was found in some persons who reported exposure to Agent Orange and in others who were never in Vietnam. On the other hand, some veterans from Vietnam had no detectible TCDD and the same is true of veterans who were never in Vietnam. The low level of TCDD in two Air Force officers and its absence in another is of special interest since their exposure to TCDD is certain and more recent than that of the veterans.

Among the twenty Vietnam veterans there was no uniformity of symptoms, either immediately after exposure, at the time of biopsy, or during the intervening period. No one symptom or group of symptoms was common to veterans with detectible TCDD in their fat. The presence of TCDD did not mean ill health nor did its absence indicate good health. No detailed statistical analysis was attempted of this small pilot series.

The TCDD content in the fat was very small, not exceding 100 ppt. Since TCDD accumulates in fat more than in other tissue, the average body concentration would be much lower. Even if all tissues contained 100 ppt, however, the concentration would be less than 0.1 mircogram per kilogram of body weight, a value below the demonstrated toxic dose to threaten health.

Conclusions: The present assay for TCDD in fat tissue does not offer a satisfactory routine test for exposure to Agent Orange, providing neither clear evidence of contact with that specific defoliant nor of absence of such contact. Moveover, the technique cannot be used to correlate body levels of TCDD and medical conditions. The assay technique is difficult and not readily available, fat samples must be obtained by surgical biopsy and the source of any TCDD detected is uncertain. The current assay method does provide a research tool under proper conditions and for specific purposes, e.g., for determining the rate of disappearance of TCDD after known exposure.

PART III

A REVIEW OF ON-GOING EPIDEMIOLOGIC RESEARCH IN THE UNITED STATES ON THE PHENOXY HERBICIDES AND CHLORINATED DIOXIN CONTAMINANTS

The use of herbicides to control vegetation has been one of the most persistent controversial subjects arising from the Vietnam Conflict. The United States Air Force applied most of these herbicides in dense jungle areas to uncover and expose hidden enemy staging areas, clear vegetation from the vicinity of military bases and along lines of communication, and to destroy enemy crops. The objectives were to provide defoliated zones that would reduce ambushes and disrupt enemy attacks. The most commonly used "defoliant" was "Agent Orange", a mixture of the two commercial herbicides, 2,4-D and 2,4,5-T,

widely employed for many years for brush control in forestry programs throughout the United States and for weed control in agriculture.

During a 5-year period from 1965 to 1970, the U.S. Air Force applied more than 40 million liters of Agent Orange containing approximately 92 kg TCDD (2,3,7,8-TCDD) in South Vietnam. Some two million American military personnel served 1-year tours during the same period. Recently, many veterans of that era have reported medical problems that possibly stem from exposure to Agent Orange during their military assignments. Their complaints have ranged from tingling in the extremities to rare forms of cancer. Some veterans have fathered children with birth defects and have suggested that the TCDD in Agent Orange is the culprit. The basis for resolving the TCDD controversy must in large measure stem from the results of scientific inquiry.

Accordingly, the Veterans Administration (VA) and the Centers for Disease Control have initiated extensive health studies of veterans exposed to Agent Orange and its dioxin contaminant during the Vietnam Conflict. Other federal agencies have initiated studies of populations potentially exposed to chlorophenols and TCDD during manufacturing processes, pesticide applications or as a consequence or improper hazardous waste disposal. Rationale for the more than twenty human studies underway is the need to determine the long-term health consequences of such exposures. Hence, studies are required on mortality, morbidity, reproduction and body burden levels of TCDD. Numerous efforts are underway to clarify the relationship of soft tissue sarcoma and phenoxy herbicides and chlorophenol exposure.

Early Federal Efforts: The United States Environmental Protection Agency, the United States Department of Agriculture and the National Institute for Occupational Safety and Health have all conducted limited studies on the potential associations of phenoxy herbicides and human spontaneous abortions and birth defects. These studies and those conducted in the industrial setting suggest that there is very little epidemiologic data associating TCDD or the phenoxy herbicides with any long-term health effects in humans other than chloracne. However, neither is there strong evidence to validate the absence of such effects. Most studies have not included sufficient numbers of subjects to detect an increased risk of an uncommon condition. Also the period of observation in many studies has been inadequate to detect an illness with long latency period between exposure and illness.

Agent Orange Registry: What has been the response of the Veterans Administration and other governmental agencies to the critical issues raised by Agent Orange? Early action by the VA included the development of a communication process for gathering scientific and medical information which would bear directly on the problem. In addition, early in 1978, the Veterans Administration established the Agent Orange Registry in order to accomplish four objectives:

(1) To identify all Vietnam veterans expressing a concern about the adverse health effects from their exposure to Agent Orange.

(2) To provide a mechanism for Vietnam veterans to voice their concerns to a physician, receive a physical examination and obtain responsible answers to some of their questions.

(3) To serve as a mechanism for follow-up of these individuals if, at a later date, new information develops as a result of the various research efforts underway or being planned.

(4) To obtain, as a by-product, some preliminary information on the current health status of the veternas who have participated in the registry.

The Agent Orange Registry provides us essentially with a listing of names and addresses, together with some background data on a self-reported group of veterans with service in Vietnam. A complete physical examination and a group of baseline laboratory tests are provided to each veteran. The information from this effort is currently being placed into a computer data bank. There are almost 100,000 Vietnam veteran who have been examined by the Veterans Administration. We are in the process of collating the data to determine whether or not there are any significant health trends in these individuals which might suggest areas for further investigation.

TCDD Assay of Human Adipose Tissue: The Veterans Administration, in cooperation with the Environmental Protection Agency (EPA) has initiated an interagency agreement to study levels of 2,3,7,8-TCDD in adipose tissue from a selected group of U.S. males.

The Environmental Protection Agency has been demographically collecting adipose tissue from the U.S. general population (i.e., by region, age, sex and race). This National Adipose Tissue Bank was initiated in 1968 and now contains specimens from over 12,000 individuals. Represented within this bank is available adipose tissue from approximately 500 males born between 1937 and 1952. Many of these individuals would have served in the military during the Vietnam-era and it is reasonable to assume that some actually served in Vietnam during the period of Agent Orange use. A retrospective study of selected chlorinated dioxins and furans may establish data on background levels of 2,3,7,8-TCDD in the U.S. male population as well as whether service in the military and especially in Vietnam has had an effect on the levels of TCDD in adipose tissue.

The study will be conducted in three phases. Phase I will be to obtain the name and social security number for the approximately 500 males noted above. This information will be used to determine military service status. Phase II will be the development of analytic methods for the determination of selected dioxins (especially the 2,3,7,8-TCDD) and furans in human adipose tissue. The method will be subjected to rigorous interlaboratory validation by an independent Analytic Referee, e.g., the Association of Official Analytical Chemists. Phase III will be the analysis of the adipose tissue and the preparation of a final report. Phases I and II should be completed within fiscal year 1983, and the report from Phase III should be available in early 1985.

Vietnam Experience Twin Study: The Vietnam Experience Twin Study was initiated by a group of research staff members at the Veterans Administration Medical Center, St. Louis, Missouri. The study will identify pairs of twin veterans where one twin served in Vietnam during the period of Agent Orange spraying and the other served in an area other than Southeast Asia. Approximately 600 pairs of twins will be examined using a series of psychologic, physiologic and biochemical tests.

The development of a protocol for the study and the establishment of a Twin Registry from which to solicit participants are now underway. The study will focus primarily on the total Vietnam experience rather than any single factor.

such as Agent Orange. If sufficient numbers of identical twin pairs are identified, there may be an opportunity to draw some conclusions regarding the effects of specific aspects of the Vietnam experience such as combat, herbicide exposure or use of insecticides.

Birth Defects and Military Service in Vietnam Study: In 1981 the Centers for Disease Control (CDC) in Atlanta, Georgia initiated a study designed to determine if Vietnam veterans are at an increased risk of having children with birth defects. Since 1968 CDC has maintained a registry of all babies born with defects in the greater metropolitan Atlanta area. Of the more than 15,000 children in this registry, approximately 7,500 had significant anatomical defects at birth. The investigators will attempt to locate and interview both parents of 5,400 of the children in this group. In addition, the parents of 3,000 control normal babies born during the same time period will be interviewed. Since the major objective of this study will be to determine whether an unusually high proportion of fathers of babies born with defects served in Vietnam, information will be gathered about Vietnam service as well as other factors which may be associated with the occurrence of birth defects. If the study demonstrates that a Vietnam veteran has an increased risk of fathering a child with a defect it may be desirable to attempt to determine if the increase is associated with Agent Orange exposure or with some other factor(s). The study is scheduled to be completed by the end of 1983.

The Air Force Health Study: In 1979 the Air Force initiated the protocol for a comprehensive epidemiologic study of the RANCH HAND personnel, a group of approximately 1,250 men who actually conducted the aerial, fixed-wing herbicide spraying missions in Vietnam from 1962 through 1971. The study is designed around the question, "Have there been, are there now, or will there be in the reasonably foreseeable future, any adverse health effects among RANCH HAND personnel caused by repeated exposure to Herbicide Orange?"

The investigation is composed of three integrated elements -- a mortality study of those individuals who have died since their exposure, a morbidity study to examine the current health status of the study subjects, and a follow-up study to look for delayed effects over the next 20 years. The mortality and morbidity study elements are being conducted simultaneously on the RANCH HAND personnel and a very carefully matched control group by the use of personnel tracking procedures coupled with an extensive review of military medical and personnel records; detailed face-to-face questionnaires to ascertain current and past health events as well as occupational and family data; and comprehensive physical examinations, psychological testing and diagnostic examinations are to be administered periodically during the follow-up phase. Results from the mortality analysis were reported in June 1983 and the results of the initial questionnaire and current health status analysis are to be released in October 1983.

Epidemiologic Study of Ground Troops Exposed to Agent Orange: Public Law 97-151 charged the Veterans Administration to "design a protocol for and conduct an epidemiological study of persons, who while serving in the Armed Forces of the United States during the period of the Vietnam conflict, were exposed to any of the class of chemicals known as "the dioxins" produced during the manufacture of the various phenoxy herbicides (including the herbicide known "Agent Orange") to determine if there may be long-term adverse health effects in such persons from such exposure. Efforts are underway by the Centers for Disease Control (through an interagency agreement with the VA) to complete a protocol and to identify suitable cohorts. This will be a huge research effort which will include interviews and examinations involving

several thousands of veterans. A major problem in the design of such a study relates to the fact that there were very few records maintained that would link specific ground troops to herbicide exposure. Another problem encountered is that it is difficult to design data collecting instruments and techniques when the health outcome variables are so ill-defined. However, much design work has been accomplished, and it is hoped that the actual study will get underway early in 1984.

Conclusion: Neither the government nor the scientific community has resolved the numerous controversies (environmental, medical, or political) involving the use of Agent Orange in Vietnam from 1962 to 1970 nor the use of 2,4,5-T within the agricultural setting of the United States, nor the impact of TCDD from improper disposal of toxic wastes. Scientific data on the long-term health effects of exposure to TCDD are at present insufficient to form a concensus. Hence, the scientific community must continue to conduct valid research on this controversial environmental and health-related issue in order to provide a reliable basis for appropriate decision-making. The Veterans Administration stands firmly committed to working closely with other agencies of the Federal Government as well as with the private sector to obtain as many answers as quickly as possible consistent with sound scientific principles in order to resolve this perplexing issue. The resolution of the controversy, however, will be achieved only following the public's acceptance of the outcome of scientific investigations. To that end, scientists must accept the responsibility for not only conducting quality research, but also for translating the results of their efforts to legislators, to the courts, to the media and ultimately to the public at large.

Dr. Robert Neal, President
Chemical Industry Institute of Toxicology

The purpose of my presentation was to review what is known about the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (Slide 1) to experimental animals and man. In regulating human exposure to TCDD, we are fortunate to have considerable information about the toxicity of this compound to humans. Information on human toxicity is generally not available on other compounds of environmental concern. However, in spite of the existence of a substantial data base, there are aspects of TCDD toxicity about which there is still considerable question. I will attempt to address some remarks to these data gaps.

In my presentation I will confine my remarks to those toxic effects in experimental animals and man which are supported by objective and scientifically sound data. As is generally the case with environmental contamination with toxic compounds, there have been numerous "scientific" opinions for the existence or absence of toxic effects as a result of exposure of experimental animals or man to TCDD which are not consistent with the existing scientific data. I believe it is essential that we differentiate between those concerns or lack or concern for human health or environmental

degradation which are based on scientific fact from those based on speculation. With these distinctions in mind groups such as yours will be in a better position to make informed decisions concerning risks or potential risk resulting from human exposure to these compounds.

There have been a number of instances of human poisoning by TCDD. This slide (Slide 2) lists some of the more important ones. First of all there have been a number of accidents in industrial facilities which resulted in exposure of workers to TCDD. Most of these accidents have occurred during the synthesis of 2,4,5-trichlorophenol by alkaline hydrolysis of 2,4,5,6-tetrachlorobenzene. On July 10, 1976, an accident occurred in Seveso, Italy, which resulted in the exposure of a substantial nonindustrial population to TCDD. The importance of this particular accident is that it resulted in the first substantial exposure of women, particularly pregnant women, and children to TCDD under conditions in which unequivocal illness occurred. One minor incident resulted in the poisoning of two, or perhaps three, chemists involved in the synthesis of TCDD. The other major incident listed was the poisoning which occurred when used oil, contaminated with TCDD, was used for dust suppression on horse show rings in Missouri, an incident with which you are very familiar.

The acute toxicity of TCDD is quite variable depending on the animal species examined (Slide 3). The guinea pig is the most sensitive and the hamster the least sensitive of all the animal species that have so far been examined in detail. The acute toxicity in guinea pigs as compared to hamsters differs by approximately 5000-fold depending on the route of administration. It is frequently stated that TCDD is the most toxic chemical known. This is, of course, not true. Botulinum toxin and tetanus toxin are more toxic than TCDD in all species examined. Also, in some species (e.g. the hamster), there are a number of compounds, including some insecticides in commercial use, which are more acutely toxic than TCDD.

What is the acute toxicity of TCDD in humans? In spite of a number of incidents of human poisoning, there is no evidence that a human fatality has occurred solely as a result of exposure to TCDD. However, in all of these incidents of accidental exposure, we have no definitive data on the dose to which humans were exposed. The only reasonably accurate dose-response data for TCDD toxicity in humans comes from studies carried out in Halmesburg Prison in Pennsylvania in the mid-1960's. In these studies, Dr. Albert Klingman of the University of Pennsylvania exposed approximately 60 prisoners to dermal doses of 0.2 to 16 ug of TCDD. These doses were reported to have caused no toxic effects. Subsequently, a similar number of prisoners (approximately 10) were exposed to larger doses, some as high as 7500 ug applied dermally in smaller doses over a period of a few weeks. These doses were reported to cause chloracne. However, no other clinical symptoms were observed in the subjects of these studies. When one considers all of these data, it is reasonable to conclude that humans appear to be one of the less sensitive species to the acute and subacute toxic effects to TCDD.

A number of studies have been performed examining the potential for TCDD to cause reproductive toxicity in experimental animals. This slide (Slide 4) shows the minimum dose of TCDD causing reproductive toxicity in various species and in various studies. The data shown here for monkeys ignores the data generated in studies at the University of Wisconsin. There is considerable controversy surrounding the conduct of these studies. In my opinion, we must await replication of these studies by another laboratory.

It is important to note that the exposure of male mice (but not females) to

high levels of TCDD for extended periods of time does not result in a decrease in reproductive capacity in that sex of that species. These data suggest that TCDD may exert its reproductive toxicity primarily in females. It will be important to examine males of other species to verify that this is the case.

There was no evidence of a statistically significant decrease in reporductive efficiency in the populations of women exposed to TCDD in the Seveso incident. I would again like to point to the particular value to toxicology of the data from Seveso. This unfortunate occurrence allows us to assess, although in a limited way, the potential for TCDD to cause reproductive toxicity in human females.

TCDD causes teratogenic effects in mice (Slide 5). The dose required is 1-3 ug/kg/day administered during the 7-15th day gestation. Exposure of pregnant rats to certain doses of TCDD caused kidney anomalies in the offspring. There has been considerable debate whether this effect is a true teratogenic effect or, alternatively, the result of the acute toxicity of TCDD to the fetus. In my opinion, the data more strongly supports the effect being the result of TCDD toxicity. To my knowledge no birth defects have been detected in monkeys born to or aborted from TCDD-treated mothers. Also, there was not a statistically significant increase in birth defects in the children born to or aborted from the pregnant women in Seveso who were exposed to TCDD. It was thought initially that an increase in birth defects may have occurred. However, a more careful examination of the data showed an obvious underreporting of birth defects in that region of Italy prior to the accident involving TCDD. When compared to a broader control base, there was not a statistically significant increase in birth defects observed in the exposed group in Seveso.

TCDD causes cancer in rats and mice (Slide 6). Tumors have been produced in mice whether the exposure is by way of the diet or applied to the shaven skin on the backs of the animals. The fibrosarcomas produced by dermal application of TCDD to mice is a particularly important observation when viewed in light of the suggestion that soft-tissue tumors may be increased in human populations exposed to TCDD.

A number of studies have been carried out looking for an increase in cancer, and in one study, mortality in humans who have been exposed or potentially exposed to TCDD (Slide 7). A study carried out in Sweden among forestry workers suggested a correlation between exposure to chlorophenols and chlorophenoxy acids and an increase in soft-tissue tumors. Subsequent studies in Finland among forestry workers and in New Zealand among agricultural workers (not shown) similarly exposed to chlorophenols and chlorophenoxy acids failed to show a similar correlation between exposure and soft-tissue tumors. Workers exposed to chlorophenols and chlorphenoxy acids are also potentially exposed to various chlorinated dioxins and in some cases to TCDD.

There are a number of confounding factors in the Swedish study which prevent the examination of the existence or absence of a cause-effect relationship between TCDD exposure and soft-tissue tumors in humans. In the first place, the chlorophenols themselves may have been responsible for the increase incidence of cancer. The compound 2,4,6-trichlorophenol is an animal carcinogen. In addition, the forestry workers were also exposed to other commercial chemicals. These chemicals may have been responsible for the increase in soft-tissue tumors. Finally, an increase in soft-tissue tumors was also observed in forestry workers not known to be exposed to preparations containing TCDD. Thus, the correlation between TCDD exposure and an increase in soft-tissue tumors is questionable at this time. However, because of these

human data and because dermal exposure of mice to TCDD causes soft-tissue tumors, further study of this issue is clearly warranted. These studies should be carried out in humans which have developed illness as a result of exposure to TCDD (See Slide 2).

An increase in gastrointestinal cancer has been observed in a population of workers poisoned by TCDD in an industrial accident. However, the fact that populations examined was small (about 50 subjects) and an increase in gastrointestinal tumors have not been detected in other TCDD-poisoned populations, raises doubts whether there is a cause-effect relationship between gastrointestinal cancer and TCDD exposure. Finally, a population of U. S. workers (121 subjects) poisoned by TCDD in 1949 have been examined for an increase in mortality and various diseases (including cancer). No increases in mortality or morbidity, including incidence of cancer or death from cancer, was seen in this population.

TCDD can cause a number of toxic effects in experimental animals (Slide 8). In addition to acute lethality, reproductive toxicity and birth defects which have been discussed earlier, TCDD can cause liver damage in some species (rat, mouse), cause a decrease in immunocompetence (mice) and cause an induction of various enzymes in a number of species. The induction of enzymes is not known to have any clinical significance.

TCDD also causes a number of toxic effects in humans. These are shown in Slide 9. Of all the symptoms listed, the development of chlorachne is the most frequent and sensitive response of humans to TCDD exposure. A careful examination of all the available data on human toxicity resulting from exposure to TCDD and the closely related compounds, the chlorinated dibenzofurans, strongly suggest that if chloracne is not present, the individual or individuals being examined have not been exposed to a sufficient dose to TCDD to cause other symptoms of toxicity. Often chloracne is the only symptom of TCDD toxicity seen in exposed humans. However, in the more severely exposed populations, liver damage and neurological effects are also seen. Other symptoms such as weight loss, hyperlipidemia, anorexia, hirsutism and loss of libido are also seen. Another reported manifestation of TCDD toxicity is porphyria curanea tarda. However, because this condition is infrequently seen in humans poisoned by TCDD, it is questionable whether porphyria cutanea tarda is caused by exposure to TCDD.

In summary, the acute toxicity of TCDD varies widely dependent on the species under examination. The current date indicate that man is one of the lest sensitive species to the acute toxic effects of TCDD.

The most common and sensitive symptom of TCDD toxicity in humans is chloracne. In more severely poisoned subjects a number of other toxic effects are seen, the most important of which are liver damage and neurological effects.

TCDD causes cancer in rats when included in the diet and in mice when included in the diet or applied to the shaved backs of this species. The current data do not indicate there has been an increase in cancer in humans exposed to TCDD. However, there is a suggestion that there may be a correlation between soft-tissue tumors in humans and the exposure to TCDD. Whether or not there is a cause-effect relationship between soft-tissue tumors and TCDD exposure will require additional studies.

Stephen M. Ayres, M.D.
Department of Internal Medicine
St. Louis University Medical School

This summary had not been received at the time this report was published. For a brief description of Dr. Ayres' speech, please refer to page II-8.

Phillip C. Kearney, Ph.D.
Chief, Pesticide Degradation Lab
Agricultural Environmental Quality Inst.
Agricultural Research Center, USDA

This summary had not been received at the time this report was published. For a brief description of Dr. Kearney's speech, please refer to page II-10.

Jurgen H. Exner
IT Enviroscience

The properties, analysis, and fate of dioxin in soil were described. Data from the literature and from IT Enviroscience's internal research program were extrapolated to potential cleanup approaches. These data show that treatment of dioxin in soil is technically feasible. These treatments, in situ photolysis or chemical treatment and on- or off-site extraction or thermal destruction in incinerators or cement kilns, can be implemented within 2-4 years and are alternatives to long-term process were illustrated by describing the development and large scale implementation of a process that destroyed 14 lbs of dioxin in Nepacco waste contained in a storage tank at Verona, MO. The time from process conceptualization to startup of the chemical destruction plant was 20 months.

Important properties of dioxin that affect selection of treatment processes are low vapor pressure, extremely low solubility in water and organic solvents, and very high soil/water partitiion coefficient. Precise analyses of dioxin in soil are difficult because of non-homogeneity and the possibility of time-dependent adsorption. Therefore, information on the disappearance of dioxin in soil must take into account the validity of the analytical method.

The fate of dioxin in soil is determined by its strong sorption to soil, by vaporization in the ng-fg/m^2 concentrations from the surface of soil, and by photodegradation. Microbial degradation is insignificant, and plant uptake is small.

Field data from Seveso and ITE internal data support rapid photodegradation of dioxin in soil. Important parameters that must be known for an in situ soil treatment process are soil condition and preparation, reaction time and

products, and environmental impact. The principle of in situ photodegradation is proven, but accurate economic information requires knowledge of the important process parameters. These parameters must be established in a demonstration project.

Similarly, the principle of extracting dioxin from soil is proven. Valid economics for such a process require understanding of the various methods of contacting solvents with soil; soil condition, consistency, and wettability; extraction efficiency; and solvent recovery and recycle.

Thermal destruction by incinerators or cement kilns requires proper feed preparation, appropriate feed rates and operating conditions, and acceptance of air, water, and ash discharges. The destruction and removal efficiency, which should be greater than 99.99%, depends on dioxin's thermal stability, the residence time, oxygen concentration, and flame configuration within the thermal oxidation system. The rate of thermal desorption of dioxin from soil and the destruction rate of dioxin adsorbed on particulate matter are other important parameters.

F. Jay Murray, Ph.D., D.A.B.T.
Manager, Industrial and Environmental Toxicology
Syntex (U.S.A.) Inc.

HEALTH EFFECTS OF DIOXIN AND ACCEPTABLE LEVELS IN THE ENVIRONMENT

The Centers for Disease Control (CDC) has recommended one part per billion (ppb) as an acceptable level of dioxin (2,3,7,8-TCDD) in soil. Their primary consideration in recommending this level was a concern for children eating soil on a daily basis. CDC's one ppb recommendation is not designed to represent an "all purpose" standard, covering all situations of dioxin contamination. Rather, it is a conservative recommendation, designed for residential property and other areas where children may eat soil on a daily basis.

Levels of dioxin in soil above one ppb should be acceptable for situations where there is less potential for exposure. In fact, CDC has stated that higher levels of dioxin might be acceptable at some other sites such as roads and parking lots where less human contact is likely. In order for dioxin to pose a potential hazard to human health, people must actually be exposed to the dioxin. For example, little hazard to human health is posed by dioxin-contaminated soil buried under a paved road since there would be virtually no opportunity for human exposure.

In humans, no conclusive evidence exists that dioxin has caused cancer, reproductive effects or birth defects. Health effects in humans include: chloracne, liver effects, neuromuscular symptoms, altered porphyrin metabolism and a number of subjective symptoms. Chloracne is considered the hallmark of overexposure to dioxin.

Pure dioxin is extremely toxic in most animal species. Dioxin has produced cancer in laboratory animals (rats and mice) given the compound over the

animals' lifetime. In animals, dioxin-related cancer has only been seen at dose levels great enough to cause other serious toxic effects. No effect levels have been established in laboratory animals. These no-effect levels are important because they are used to predict acceptable levels for humans.

Factors which may affect the potential hazard of dioxin in soil include: concentration of dioxin, location (e.g., surface versus buried), accessibility (e.g., restricted area), type of human activity (e.g., play area for children), presence of grass or ground cover, opportunity to accumulate in food chain, proximity to ground water/streams, potential for erosion, and the presence of oils or solvents. In conclusion, standards for sites must be determined on a case-by-case basis since the circumstances and potential for exposure will vary.

Henry Falk, M.D.
Chief, Special Studies Branch
Chronic Disease Division
Center for Environmental Health
Centers for Disease Control

This summary had not been received at the time this report was published. For a brief description of Dr. Falk's speech, please refer to Page II-11.

CHAPTER 3

OPTIONS FOR REMEDIAL ACTION

Introduction

A number of different options for remedial action have been proposed. This chapter examines in detail the current technology available to stabilize, treat, or dispose of the dioxin contamination in the state.

It must be stressed that certain options may be more suited to some sites than others. Therefore, each option must be compared on a site by site basis. This chapter attempts to review all possible means of remedial action, but does not recommend one option over another. Also, several of the technologies discussed may not be developed enough for immediate, full scale use. And while every attempt was made to include all possible technologies, exclusion of any technology does not necessarily mean that it is not a viable technology.

A great part of the information in this chapter was supplied by CH_2M-Hill, the Environmental Protection Agency's feasibility contractor for the Minker/Stout site. A summary of their remarks before the Task Force is available in Appendix VIII.

Stabilization In Place

Possibly one of the simplest means of dealing with the situation in terms of actual handling of the contaminated soil is to stabilize or secure it in place. This can be accomplished in the following manner.

In order to insure that the contaminated soil is unable to move, and that the dioxin cannot be leached from the soil, some sort of impermeable barrier must be installed. Once the extent of the contaminated area has been determined, a wall of impermeable material is installed around the site perimeter to a depth which penetrates bedrock. This wall or curtain can be made in several different ways. A grout curtain of cement can be installed by drilling a double wall of large diameter holes around the site down to bedrock and filling them with the cement, which will then spread to form the seal. Or a trench can be dug around the site and filled with a slurry of bentonite mixed with soil. The bentonite will then expand to fill any cracks or crevices in the rock and form a seal.

Along with sealing the perimeter, a clay cap at least 4 feet thick must be placed over the site to seal it from above. It is imperative that no groundwater movement occurs through the site.

It is important to note that the success of this method of containing the the contamination is highly dependent on site geology. If the site is unstable geologically, for example with large cracks and fissures in the rock, complete containment of the soil cannot be insured. Also, this method requires a great deal of onsite construction, and once completed, must be monitored indefinitely.

Another, somewhat simpler means of fixation in place is the addition of a fixative directly to the top layer of soil. Either an inorganic fixative or an organic polymer can be used. Examples of inorganic fixatives include cement

or flyash, and organics include polyurethane, polyvinyl acetate and urea formaldehyde. The fixative is sprinkled onto the soil surface and tilled in, forming an impermeable cap over the contamination. Disadvantages of this method include the tendency of the fixative to break down over long periods of time.

The great advantage of this method is that contact with the soil itself is minimized in that the soil remains undisturbed. Of course, this method does not remove or destroy the dioxin, but minimizes its availability to the environment.

On Site Storage

Onsite storage essentially involves creating a landfill directly on the site. Some type of structure is constructed either above or below ground to hold the contaminated soil, and prevent exposure to the environment.

With storage below ground, some type of impermeable liner such as clay or a synthetic sheet must be used in order to prevent possible groundwater contamination. Some type of leachate collection system and monitoring wells are also necessary.

Above ground storage can be accomplished with either a concrete structure or an above ground cell with an impermeable clay or synthetic liner. In either case long term monitoring is required.

This method involves a slightly increased risk of exposure in that the soil must be excavated, causing possible dust formation. One advantage is that contaminated material from all the sites can be consolidated on a single site with proper geologic and geographic requirements. Of course, this would involve some highway transport of the wastes, with the attendant increase in risk.

Transport To Secure Landfill

Transport to a secure landfill involves many of the same principles as on site storage. This option includes excavation of the contaminated soil, and removal from the site by truck to a properly permitted hazardous waste landfill.

Since highway transport would be necessary with this option, the vehicles actually transporting the waste would have to comply with the Department of Transportation (DOT) regulations. Up to this point, the only contaminated soil which has been shipped has been for samples. These samples were classified as a Poison B. If bulk shipment of the contaminated soil stays under the same classification, then the soil would have to either be packed into drums or other containers which met DOT specifications for Poison B, or shipped in a tanker which would also have to meet DOT specifications for Poison B.

Once the contaminated soil reaches the landfill, it is treated in much the same manner as in on site storage. Either an above or below ground cell is constructed to hold the material, and all monitoring requirements become the responsibility of the landfill operator. Two landfills exist within a 600 mile radius which are capable of taking the soil.

A major advantage of this option is that with replacement of the excavated soil, the site once again becomes habitable. Some of the disadvantages include

the large cost of transport for the distance required, as well as the increased risk of exposure, both from dust formation on site during excavation, and accidental spillage during highway transport. And like on site storage, this method does not destroy dioxin, but minimizes its availability to the atmosphere.

Incineration

One of the most commercially available means of destroying the dioxin in the contaminated soil is by incineration of the soil. Incineration is widely used in the destruction of other hazardous wastes, and can be considered a proven technology.

The basic principle of incineration is to destroy the dioxin molecule by thermal degradation, and several different incineration techniques are available to accomplish this. The first is by direct incineration of the contaminated soil. Although no test burn data on dioxin is available, by comparison with other highly chlorinated organics it is felt that a temperature of 2300°F and a residence time of 2 seconds would be sufficient to destroy the dioxin. Some of the problems with direct incineration of the soil include the thermal inefficiency of heating that large a quantity of soil to 2300°F, and the slagging and other problems which would occur inside the incinerator.

Another incineration technique which would avoid the problems mentioned above is pyrolytic incineration. This is a two-step process in which the contaminated soil is first placed in some type of rotary hearth or other kiln and baked at 1600°F to drive off the organics, including the dioxin. The organics rich gas stream is then fed to an afterburner operating at 2300°F with a 2 second residence time to destroy the dioxin. In this way, the soil itself is not subjected to the higher temperatures.

No matter what basic incineration techniques are used, certain requirements must be met in regards to site preparation, emission controls, and the like. Of course, the soil must be excavated, and some type of size reduction facility will be needed, since the excavated material will probably contain trees, rocks, concrete, road materials, and other materials unsuitable to feed directly into an incinerator. For this size reduction facility, the feed will either have to be dried out or slurried to facilitate handling. The rocks and other large objects will be separated from the soil, screen graded, and crushed in some type of crusher such as a ball mill. If the feed is slurried in, then some type of concentrating step must be performed and the resultant feed put in some type of form suitable for feed into the incinerator, such as pellets. All soil handling should be done by enclosed conveyor, with sprays, splash guards and other suitable dust suppression equipment on all handling equipment.

The actual incineration of the materials can be accomplished by either of the techniques outlined above, in addition to the following emission control requirements. Some type of dust collector such as a bag house is needed to trap particulates from the rotary kiln. The trapped particulate can then be fed back into the rotary kiln. Emissions from the afterburner can be trapped by a venturi scrubber in series with a packed scrubber to trap any organics in the effluent. Process water from the packed tower must then be treated, possibly by reintroduction to the kiln of the solid residues removed.

One possibility not yet mentioned would be to convert an existing area cement kiln to burn the contaminated soil. Several such kilns exist in the

eastern part of the state and are not currently in use. Most if not all of the kilns have size reduction equipment already in place. However, the kiln would have to be retrofitted extensively with adequate pollution control devices as outlined above to ensure containment of the dioxin.

Although the technology to incinerate the contaminated soil is currently available, several questions remain to be answered about matters such as ash disposal. Estimates place the amount of ash which will remain at 80% of the original volume of incinerated soil. Since no test burn data is available for dioxin in soil, the residual amount of dioxin in the ash has yet to be determined. And this ash must still be considered a hazardous waste by definition, and would have to be disposed of in a secure landfill. However, if the residual level of contamination in the ash is within acceptable levels, the possibility exists that the ash can be delisted, making disposal much easier. In the case of the cement kiln, the ash may possibly even be used as a component of cement.

The major advantage of incineration is the fact that it is an accepted, proven technology which is already in use on similar compounds. The major disadvantage is the increased risk of exposure, not only from dust caused by excavation of the soil, but from volatilization of the dioxin from the incineration process. Another disadvantage is that the ash is, by definition, still a hazardous waste.

Solvent Extraction

Extraction is a process whereby the dioxin is stripped from the contaminated soil with some type of solvent, which is then treated to remove or destroy the dioxin. The purpose of this method is to get the dioxin into a medium more suitable to work with, and to leave decontaminated, and possibly usable, soil.

A number of different common solvents exist which would be capable of extracting the dioxin from the soil. Examples of such solvents include toluene, hexane, and freon. The solvent that works the best will have to be determined by testing. A less common extraction technique is the use of supercritical fluids. A supercritical fluid is a gas such as carbon dioxide which has been compressed into its liquid phase. Supercritical fluids have shown promise as extracting solvents, and hold one advantage over common solvents. Most of the common solvents which would be suitable as extracting solvents are also highly toxic in and of themselves. And even if the soil is put through a dryer, a certain amount of the solvent will remain with the soil, usually 1-2% by weight. Use of a solvent such as liquid carbon dioxide would not pose a risk to human health. However, the use of a supercritical solvent has some major drawbacks. First, the technology has not yet been developed to a commercial scale. Secondly, working with anything under extreme pressure always increases the risk of explosion or other mishap.

Once a suitable solvent is chosen, the actual extraction process can be examined. First, size reduction equipment will be necessary as described in the section on incineration. The actual extraction will require some type of multi stage contactors. The soil is washed with solvent in the contactor, the solvent is then drained off, and additional fresh solvent is added. This process is repeated until the dioxin in the soil is reduced to an acceptable

level. Current estimates place the aproximate number of washes necessary at 10 to 15. When the soil is deemed clean, then it must be dried to remove as much solvent as possible. The contaminated solvent from the various washes is concentrated by means of distillation, or cleaned by some type of adsorption process using activated charcoal or resin. All of the steps described above must be done under vacuum, to insure that no contamination is leaked to the environment.

The last step would be to treat the concentrated solvent in some manner to remove or destroy the dioxin. This can be done in a number of ways. One process which has already been performed is that of U.V. photolysis. Ultraviolet light is shone on the contaminated solvent, ultimately breaking the bonds in the dioxin molecule. Gamma radiation works in a similar manner. Another process is the addition of a chemical reagent to the solvent to dechlorinate the dioxin molecule. Still another option would be to incinerate the contaminated solvent.

Ideally, the major advantage of this method is that the clean soil can be returned to the site, and the contaminated solvent is more easily treated. Also there are a variety of commercially available solvents capable of extracting the dioxin. Unfortunately, there are a number of disadvantages associated with this method. First, no doubt exists that dioxin can be extracted from soils. This is how samples are tested for dioxin. However, no attempt has been made to demonstrate this process on a commercial or even a pilot scale for the treatment of dioxin. Another major drawback is the toxicity of most solvents which are capable of extracting the dioxin. If 1 or 2% by weight of the solvent is left in the soil, chances are the soil would be more toxic than it was prior to removal of the dioxin. Also, liberating the dioxin from the soil with a solvent increases the availability of that dioxin to the environment, increasing the risk of exposure.

Biodegradation

One of the least expensive and most environmentally desirable techniques for breaking down large organic molecules is to subject the molecules to the action of microorganisms. Numerous studies have examined the susceptibility of dioxin to microbial decomposition, mostly in the uncontrolled environment.

Early studies appeared to indicate that dioxin in soil in the environment was disappearing, possibly due to biodegradation. Unfortunately, later studies showed that the disappearance was due to the increasing difficulty of recovering the dioxin which bound more tightly to the soil with time, rather than any microbial action on the dioxin molecule.

More recently, research programs are being conducted to establish organisms which will ultimately degrade dioxin and other chlorinated ring structures directly in the environment. These projects seek either to modify naturally occuring organisms or to apply recent advances in recombinant DNA technology to genetically engineer organisms which are capable of degrading dioxin.

Many of the studies now being done are focusing on the genetic modification of a number of organisms such as anaerobic and aerobic bacteria, yeasts, and algae. Ideally, the organism created would be able to survive in the environment with direct application to the contaminated soil. A more realistic approach may be to engineer an environment more suitable to the organism, and place the contaminated soil within the artificial environment. This approach would allow the control of specific conditions such as temperature, light, oxygen, and pH to insure the survival of the organism.

Following is a sampling of the research projects under way to study the development of organisms capable of degrading dioxin and other chlorinated ring structures.

At the University of Illinois, a bacterial culture capable of degrading 2,4,5-T has been developed by gradually exposing a mixed culture to increasing strengths of the compound. Research is currently underway to develop a variant of the 2,4,5-T bacteria capable of digesting dioxins by use of the same gradual acclimation method. At the University of Helsinki in Finland, researchers are studying the degradation of pentachlorophenol by organisms either anaerobically or aerobically in an effort to understand and apply the mechanisms involved to dioxins and other chlorinated ring structures. And at the University of Cincinnati, studies are being conducted on yeasts to determine if mammalian genes for chemical degradation can be successfully implanted or transferred.

If some type of organism can be discovered which can indeed biodegrade dioxin, the advantages are obvious, both economically and with respect to handling of contaminated materials. However, it must be stressed that at this point, no organism has been discovered, and such a discovery could be many years in the future.

In Place Treatment

The option of in place teatment is an attractive one in that the contaminated soil could be left in place and treated in some manner to destroy the dioxin. There have been a number of different methods proposed to accomplish this. However, most of the proposed methods have not been developed to the extent that they can be considered as viable technology. Some of these methods are described below.

Perhaps the most technologically developed and the most familiar method is that of ultraviolet (uv) degradation, also know as photolysis. Uv degradation was discussed briefly in the extraction section of this chapter in connection with destruction of dioxin in a solvent medium. When used for the decontamination of soils, the method works as follows. Some type of hydrogen donor such as olive or vegetable oil is applied to the surface of the contaminated soil. Then some type of uv light emitting unit is passed over the soil surface, and the dioxin molecules within reach of the uv radiation are destroyed. Then the surface is tilled to expose fresh soil and the procedure is repeated. This method is most suited to areas where the contaminated soil is shallow. However, some uncertainty exists as to the efficiency of this method, because uv radiation cannot penetrate the soil to any depth, and no estimates are available as to the number of passes necessary to appreciably reduce the dioxin level in the soil.

Another possible method of in place treatment which is similar to uv degradation is the use of gamma radiation. Like uv radiation, gamma radiation destroys the chlorine bonds within the molecule. However, gamma radiation is still in the experimental stage, and will need further developement before it can be considered a viable technology.

Chemical treatments have also been researched in regards to in place treatment. Work has been done on the addition of a sodium containing compound such as sodium polyethylene glycol to the soil along with a hydrogen donor. The sodium compound would then act to dechlorinate the dioxin molecule. But once again, this method is still experimental, and needs further work before it

can be added to the list of viable alternatives.

Biodegradation can be considered as an in place treatment method, because of the possibility at some point in the future of simply adding the proper organism directly to the soil to decontaminate it. However, as discussed in the previous section on biodegradation, no organism has been isolated or created which is capable of degrading dioxin yet. Current estimates place the length of time to possibly develop such an organism at 5 years or more.

The advantage of in place treatment is obvious in that soil handling and site disturbance are minimal. However, the disadvantage is the lack of a currently available means of treating the contaminated soil in place.

Stabilization In Place Until New Technology Develops

Throughout all the sections in this chapter, certain technologies have been discussed as having merit, but not being available at this time because of a lack of technological or commercial development. The purpose of this last potential remedial action is to provide an opportunity to allow these and other emerging technologies a chance to develop so that they can be considered as viable options in solving Missouri's dioxin problem.

Initially, some type of interim stabilization measures would be implemented, such as capping or sodding to combat erosion, and other measures to insure that no movement of dioxin is occuring. Site access would be restricted to reduce exposure to the contaminant, and a monitoring program would be implemented to see if any movement is occurring. Concurrently, the development of new technologies for the destruction of dioxin would be observed closely and encouraged.

Some of the emerging technologies as mentioned in previous chapters are as follows. Extraction, especially with supercritical solvents, although a proven technology at the bench scale, has yet to be proven commercially for this type of contaminated soil. Biodegradation holds eventual promise as a simple, effective method, but as yet no organism has been discovered that can successfully degrade dioxin. Gamma radiation and chemical treatment with sodium reagents are two possible methods of in situ treatment which require further study.

Still further emerging technologies which were not mentioned in previous sections include lasers, wet air oxidation, and plasma arcs. Treatment with lasers involves the use of a beam of even intensity to destroy the dioxin molecule. Wet air oxidation involves suspending the contaminant in an aqueous solution at elevated temperature and high pressure, and bubbling air or oxygen through the solution, oxidizing the dioxin molecule. The plasma arc utilizes high energy radiation to almost instantly decompose the dioxin into elemental components.

The possibility exists that even more methods of destroying or containing dioxin will be developing in the near future. The option of stabilizing in place and waiting for new technology will provide a wider range of final remedial actions from which to choose.

CHAPTER 4

SUMMARIES OF REMEDIAL ACTION PROPOSALS FROM INTERESTED FIRMS

This chapter contains summaries of remedial action proposals which were presented to the Task Force by various waste disposal and management firms. These summaries were prepared by the firms, and illustrate the commercial stage of development of the various technologies.

Acurex Waste Technology, Inc.

Acurex Waste Technology, Inc. (AWT) is a wholly-owned subsidiary of Acurex Corporation, a diversified technology company of about $50M sales headquartered in Mountain View, California. Acurex activities include environmental and waste-treatment technologies for U.S. EPA and commercial processing of PCB oils for industry and utilities. Dr. Weitzman is a chemical engineer, chief scientist of AWT, and Manager of the Cincinnati laboratory. Dr. Schraub is Manager of Market Development for Acurex Energy and Environmental Division.

AWT is utilizing a proprietary EPA-approved commercial process to treat PCB oils. The PCB molecule is destroyed by chemically combining the chlorine atoms on the PCB molecule with metallic sodium, forming NaCl (table salt) and a small amount of long-chain polymer which is not acutely toxic and is disposable. This novel process also destroys the chemically similar dioxin compound, 2,3,7,8-TCDD, by the same sodium reduction reaction yielding salt and polymers. The destruction process is combined with solvent extraction soil cleaning methods using a special blend of AWT solvents to make up the Acurex Dioxin-Soil Cleanup Process described in this testimony.

The Acurex Dioxin-Soil Portable Cleanup Process consists of these steps:

1) Obtain permits and approvals.
2) Move portable equipment to contaminated site. Equipment includes enclosed soil moving front loader; required number of soil washing modules (Tanks in which soil, rocks, etc, are washed in solvent with agitation); Solvent Reclamation Unit; Clean Solvent Tank; Analytical Laboratory and Records Office for verification and process quality control Sample analysis; Personnel Trailer: special equipment; toilet and shower and clothes dry-cleaning unit; Water truck.
3) Prepare site including security, wetting of soil for dust control, size reduction to fit into about 20 cu yd washing modules.
4) Scoop soils, etc. into washing modules.
5) Fill with clean solvent and agitate at room temperature and pressure for about one-half hour

6) Pump out solvent and refill with clean solvent and repeat washing process until solvent shows soil to be below desired contamination level (such as 1ppb). Note that a unique relationship exists between dioxin left in soil and that extracted into the solvent.
7) The contaminated solvent is then purified for recycle in a low-power standard distillation process.
8). The remaining small volume of solvent containing all dioxins is transferred to a reactor where Acurex reagents and sodium metal dispersion are added to destroy the toxic dioxin by removing chlorine atoms.
9) Dispose of the small volume of dioxin-free sludge (e.g., 100,000 cu yds soil produces less than 1 cu yd of sludge).
10) The safe soil is returned to its original location or placed in suitable location as regulations allow.
11) Equipment is removed and site regreened.

The AWT process has been verified in Missouri by an actual cleanup of a sample of Minker-Stout soil provided by the Department of Natural Resources at the University of Missouri Environmental Trace Substance Center in Columbia during February, March and April of 1983. Some analytical problems (interference peaks in the gas chromatograph analysis) were encountered but overcome by the combined efforts of DNR, U. of Missouri and Acurex staff.

The Acurex Dioxin-Soil Portable Cleanup Process is estimated to cost about $250 per cubic yard of soil for a 10,000 yard size cleanup job of which $100/yd is the variable cost.

The R&D phase and the initial laboratory demonstration phase are now complete. We believe that AWT process to be a viable technology and a serious candidate for large-scale dioxin soil cleanup and destruction. The next step is a pilot-scale (e.g., one full size washing module) field demonstration affecting a small dioxin site cleanup. Such a program was suggested at a cost of between one-half and one million dollars and a one-year schedule.

In summary, AWT has a novel process to destroy dioxins in soil which is already demonstrated to work on the Minker-Stout soil. The Acurex Dioxin Soil Portable Cleanup Process has these benefits: cleans dioxins, PCB's and other halogenated organics from soil down to a specified level; destoys the dioxin molecules; is safe using non-flammable, non-toxic solvents; is controllable and verifiable, creates no secondary pollutants or migration of existing pollutants; and is already demonstrated in Missouri.

We believe this techology merits thoughtful consideration in the solution to the Missouri dioxin soil problem.

Chemical Waste Management

Late in 1982, then the dioxin problem in Missouri began to receive a great deal of attention, Chemical Waste Management, by virtue of its extensive experience in hazardous waste site mitigation, began a search for a solution to the problem.

In the selection of a project approach, nine key factors were considered:

1. Public health and safety during project implementation and final completion.
2. Technical feasibility.

3. Operational soundness.
4. Provision of an environmentally sound and defensible solution.
5. Compliance with regulations.
6. Timing.
7. Cost.
8. Public reaction/opinion/perception (in Missouri).
9. Public reaction/opinion/perception (in other states).

Using these key factors, four potential treatment/disposal options were evaluated, breaking each option into positive and negative factors. After evaluating incineration, secure burial, treatment, and site capping/encapsulation, the following conclusions were reached:

1. Due to the large volume of soil, destruction of dioxin with the soil is cost prohibitive;
2. Since dioxin is the major concern, it should be extracted from the soil in order to reduce volume;
3. Dioxin which is excavated/extracted should be destroyed through incineration;
4. Again, due to the volume of "low level" dioxin-contaminated soil, removal and destruction of dioxin with the soil is cost prohibitive;
5. Site capping/encapsulation should be an alternative solution for select "low level" sites;
6. Because of public reaction/sensitivity by other states to receiving dioxin, as much of the dioxin processing/disposal should be done within the State of Missouri as is possible.

In light of these conclusions, Chemical Waste Management recommends the following primary operations:

1. Excavation of highly contaminated soils and replacement with clean fill;
2. Site capping/encapsulation of "low level" dioxin contaminated sites;
3. Extraction of the dioxin from the soil;
4. Disposal of treated soil in a secure landfill;
5. Destruction of the dioxin in the extract medium via the ultraviolet light process;
6. Incineration of the treated extract medium at sea via one of CWM's ocean incineration vessels.

Based upon the information at hand, Chemical Waste Management estimates time required for completion of the project to be from 14 to 24 months, with costs ranging from $22 million to $65 million, depending upon the establishment of acceptable levels of contamination and the number of sites to be cleaned up.

Chemical Waste Management, in conjunction with Battelle Memorial Laboratories, is currently conducting tests on dioxin contaminated soils. When those tests are complete, the preliminary estimates will be further refined.

In terms of the key factors and the evaluation of potential treatment/disposal options, Chemical Waste Management believes that the primary

operations outlined above represent the most environmentally sound and cost-effective solution to the dioxin problem in Missouri.

Critical Fluid Systems Inc.

Critical Fluid Systems, Inc., is a chemical process engineering company that designs and sells a variety of proprietary extraction systems based on critical fluid technology. These new extraction techniques fill a range of processing needs in such industries as pharmaceuticals, food and organic chemicals as well as waste treatment. Critical Fluid Systems, Inc., was formed in January 1980 as a subsidiary of Arthur D. Little, Inc., to commercialize industrial applications of the patented technology. The company is headed by Dr. Richard P. de Filippi, who initiated the technical development work in the international consulting firm's laboratories in 1976; Critical Fluid Systems' offices, laboratories and pilot plant are located in Cambridge, Massachusetts.

Critical Fluid System's verstile technology, is based on the use of condensed gases as extracting solvents, which provide more economical, and more efficient, alternatives to distillatin, conventional solvent extraction and various incineration and landfill techniques for the management of hazardous wastes. For example, one critical fluid process can be used to clean up soils contaminated with toxic materials.

The State of Missouri faces a massive cleanup of dioxin contamination in Times Beach and other communities. The removal of dioxin presents some very special economic and technical problems - problems which widely used, conventional solvent technologies for waste treatment have not yet succeeded in solving.

The use of critical fluid extraction to strip soils of contaminated material is technically feasible and, in the view of Critical Fluid Systems' engineers, worth trying at Times Beach. Although never applied specifically to dioxin, the technology has been successful in extracting other chemicals and materials from soils. For example, in laboratory tests, Critical Fluid Systems' engineers have separated lubricating oils from steel-making mill scale, diesel oil from cuttings produced in oil well drilling operations, and vegetable oil from spent bleaching clays in food processing. These test results provide reason to believe that the technology might succeed in removing dioxin from soil substrates.

Company officials emphasize, however, that success in such special problems can never be assumed. They propose, therefore, that the State of Missouri underwrite a small scale preliminary test of the efficacy of critical fluids in Times Beach dioxin/soil samples. The company would work with an approved EPA contractor to process samples using a variety of condensed gas solvents and operating conditions. At the completion of the test program, which, if appropriate, would include preliminary estimates of capital and operating costs for a commercial scale facility, a recommendation would be made on the feasibility of proceeding with subsequent phases leading to construction of a full-scale processing plant to be operated by a major waste management company.

The special properties of critical fluids in separating substances have been known to chemists for many years but have only recently been applied on a commercial scale. The first commercial applications have been to extract hops for brewing and to decaffeinate coffee.

Critical Fluid Systems' patented extraction method utilizes fluids that are liquefied gases. At a certain combination of temperature and pressure, these

gases reach what is called their critical point. At this point the gases are neither liquid nor vapor but have many of the solvent properties of both. These properties make extraction more rapid and efficient than processes using distillation and coventional solvent extraction methods.

Critical Fluid Systems is currently working under contract to a number of government agencies on critical fluid development projects that include applications for treating and decontaminating solid wastes, extracting chemicals, including pesticides, from waste water, and regenerating activated carbon and other adsorbents used in manufacturing.

SCA Chemical Services, Inc.

Decontamination or destruction of the dioxin contaminant in large volumes of material (soil, construction debris, and furniture) presents challenges that exceed current proven state-of-the-art destruction or decontamination techology. One method has been burial of the contaminated material in specially constructed cells. When material contaminated with dioxin is buried, the problem has been placed in storage for others to solve at a later date. Decontamination or destruction of the contaminant dioxin found in small quantities in the large volumes of contaminated soil located at the various sites in Missouri poses a technical and waste management challenge of unprecedented magnitude. SCA Chemical Services, Inc., one of the nations's largest hazardous waste treatment and disposal companies is pleased to accept that challenge.

SCA recognizes that there is no proven contamination or disposal technology capable of decontaminating large volumes of solid contaminated with dioxin levels ranging from 1 to over 300 parts per billion. The actual level of decontamination to be reached in order to certify the soil free of dioxin and suitable for unrestricted use has yet to be established. Therefore, SCA assumes that any acceptable decontamination or destruction process must achieve average levels of dioxin significantly less than 1 part per billion in the resulting decontaminated material. To date, no large-scale treatment or disposal process has been operated with documented destruction of a contaminant, especially one as persistent as dioxin, bonded to soil particles or soaked into concrete block, to achieve concentration levels significantly below 1 part per billion. It is tempting to make assumptions that certain technologies will work; however, a much more scientific approach is required in order to select candidate treatment processes. Initial evaluation by SCA for the preparation of this proposal has determined that there is no proven off-the-shelf system available to meet the dioxin decontamination challenge.

The existing situation is further clouded by the fact that dioxin is currently regulated by the Toxic Substance Control Act (TSCA). EPA proposed new regulations that would transfer dioxin from the TSCA regulation to the Resource Conservation and Recovery Act (RCRA) regulation in accordance with 40 CFR 261-265 and 40 CFR 122. After the public comment phase, the regulations will be revised to reflect public comment and concern. At this time, it is difficult to project whether or not dioxin will be transferred from TSCA to RCRA and, if so, what the content of the final regulations will be. In either case, any material contaminated with dioxin will be subjected to specific

controls and regulations. Such specific controls and regulations will limit the number of commercially available treatment facilities permitted to receive or treat dioxin contaminated material. In addition, the public reaction in host states to the import of large amounts of dioxin contaminated soils must be considered. Because of these many unknowns, it is prudent to assume that the disposal or decontamination of dioxin contaminated materials must be accomplished within the boundaries of Missouri.

In order to meet the technical challenges associated with the successful design, construction and operation of a dioxin contaminated materials decontamination and disposal facility, a multi-disciplined technical and management team will be required. Such a team must have access to the most advanced technologies available in the world, be highly skilled in the evaluation and testing of all types of candidate decontamination systems, be capable of translating conceptual design to a final facility design and supervising the construction of such a facility, be knowledgeable of all regulations and hazardous waste management techniques, and be capable of operating the facility in the most effective and safe manner possible. SCA has assembled such a team to respond to the challenge issued by the Governor's task force on dioxin and the Missouri Department of Natural Resources. The team is comprised of the best technical engineering, construction management, and operational personnel available in the United States today. With the exception of Battelle Columbus Laboratories, all team members are residents of Missouri.

The initial phase of the project will be screening and evaluation of candidate technologies. Laboratory tests may be required in order to complete evaluation of these technologies. The selected technology must be verified by a full-scale pilot operation prior to commitment of the process to final engineering design. Battelle Columbus Laboratories has been selected as the technology team member because of their unequaled capability and knowledge of all types of chemical processes, their extensive laboratories and small-scale test facilities, their current experience as a leading laboratory performing analysis of dioxin contaminated soil samples from Missouri, and their extensive experience in evaluating similar types of problems for the United States Environmental Protection Agency and the United States Army. Battelle has recently completed a $250,000 technology evaluation study for the U.S. Army to determine the best means of decontaminating large volumes of toxic materials, chemical agents and chemical munitions. Battelle Laboratories, Inc. is a not-for-profit research and development center with revenues exceeding $400,000,000, much of which were directly applicable to waste management. Battelle is a recognized authority on various types of hazardous waste treatment technologies including incineration, solvent extraction, and genetic engineering. Battelle has current experience in all types of processes suitable for consideration for decontamination of dioxin contaminated materials.

Once the decontamination technology has been thoroughly tested and confirmed it must be translated into a facility design suitable for construction. SCA has chosen the Fru-Con Corporation, with World Headquarters in Ballwin, Missouri. Fru-Con is a full service engineering and construction corporation. Two elements of Fru-Con are participating in this project. Fruco Engineers, Inc. is an experienced engineering firm with an international reputation for excellence specializing in the design and construction

management of cement plants, chemical plants, refineries, industrial facilities, and major buildings. Fruin-Colnon Corporation Contracting Company will provide construction of the facilities. Fruin-Colnon are experienced constructors who have constructed numerous cement plants, chemical plants, refineries, wastewater treatment facilities, and major buildings throughout the State of Missouri, the United States, and internationally. SCA Chemical Services, Inc., a wholly-owned subsidiary of SCA Services, Inc. is one of the major solid waste and hazardous waste corporations in the United States. SCA Chemical Services, Inc. (SCA) operates six major hazardous waste treatment and disposal facilities throughout the United States, has major research and development laboratories in Buffalo, New York. One of its six operational facilities owns and operates the largest commercial hazardous waste incinerator in the United States located near Chicago, Illinois. SCA is an experienced hazardous waste management company that has placed its emphasis on high technology treatment of hazardous waste. It is SCA's established philosophy that land burial of hazardous waste is the option of last resort and should only be utilized when no other treatment technologies are available. The SCA project will be directed by Mr. James L. Boyland who is currently Director of Business Development located in St. Louis, Missouri. Mr. Boyland served on the Department of Natural Resources ad hoc committee for hazardous waste and is experienced in hazardous waste regulations and hazardous waste management.

The SCA team does not approach the decontamination of dioxin contaminated material with preconceived ideas or proprietary processes. Rather, it will evaluate the situation, all relevant data, and proceed to identify those solutions that appear practical. It is the purpose of this proposal to provide the State of Missouri with the option to go forward with the technology development, design, construction, and operation of a dioxin decontamination facility. Such a facility may prove to be necessary in the event that other licensed hazardous waste disposal or treatment facilities are unable or unwilling to accept the large volumes of dioxin contaminated soils from Missouri. The high cost of transportation of such large volumes of soil to remote facilities is also a major cost consideration. With a proper plan and qualified contractors, the State of Missouri should be able to request and obtain federal funding for the required technology development, design, construction, and operation of a dioxin contaminated facility located within the State of Missouri. The SCA team stands ready to support the State of Missouri in any way possible in order to achieve such a goal.

Rollins Environmental Services, Inc.

Presently, there exists many options for the destruction or disposal of extremely hazardous waste (i.e., PCB's, radioactive waste, organic pesticides and herbicides) and many of the same methodologies are being suggested for the treatment of dioxin waste. Unfortunately, there is very little data, if any, on the effectiveness of these methods to treat dioxin materials. Compounding this problem is the large volume of dioxin waste material requiring treatment in Missouri. Most of the present options are not applicable to a large scale problem such as this, except at extreme costs.

Rollins Environmental Services (TX) Inc. (RES) presents the following discussion of thermal oxidative destruction, solvent extraction and land disposal methods that may have application to the dioxin problem. Suitability of these options is based on economics, scale of operation and practicality of the solution. To minimize the number of cost options, we assumed the establishment of a local treatment facility in the St. Louis area for on-site versus off-site (out-of-state transportation cost) treatment.

Thermal Destruction

Our best estimate of the cost of off-site incineration is $234,806,000.00. This number includes excavation, transportation and incineration at a permitted facility. The project time for off-site incineration is estimated to be 3-5 years. On-site incineration with a portable or temporary unit would also be a time intensive option costing $411,100,000.00 and taking greater than 20 years to complete the incineration of the waste with available technology.

Equally important is the disposal of large quantities of incineration ash generated by this disposal method. If the waste ash can not be delisted, it will require disposal in a Class I landfill, further increasing the total cost of incineration.

Solvent Extraction/Oxidative Destruction

Both solvent extracton and oxidative destruction methodologies, in theory, are viable options for dioxin removal, but the technological-operating problems to apply these methods would be more cost intensive than incineration.

Land Disposal

Land disposal, as an option for the treatment of extremely hazardous waste is quickly becoming obsolete with respect to other treatment technologies. The issue of securing a hazardous waste below grade is being questioned because of the uncertainties of these facilities.

Rollins Environmental Services (TX) Inc. is engineering (is developing) an above ground closure method that addresses the problems associated with the below grade secure landfill. The advantages of our above ground closure method include:

1. Only one handling is required and this is bulk handling. Therefore, dissemination of the material is greatly reduced.
2. If the contaminated soil is land-disposed in a secure, aboveground, well monitored site, the problem of future contamination is eliminated.
3. The time of removal from public area is rapid.
4. Transport costs and hazards of shipment to a centrally located above ground closure are minimized.

5. Dioxin has an extremely low solubility in water. If protected from rainfall and surface runoff, it is non-migratory.
6. There is a half life to dioxin - but this may depend on matrix and environmental conditions.
7. There are reports of 5 strains of bacteria which are active with dioxin - leading to the interesting possibility that the material may be inoculated to speed dioxin destruction.
8. Naturally, costs would be appreciably lower for local land disposal.

Above ground land disposal is an environmentally sound method for this waste because it is protected from rainfall and runoff contamination. The construction of a central storage for all dioxin waste, if monitored by a responsible organization, will give the best remedy for the available funds until a final solution is found.

Cost Estimates for Above Ground Closure

Past project experience would indicate that the entire contamination (as presently known) in the St. Louis area could be contained in a twenty acre site with a twenty foot high above ground closure. Assuming the same transportation and excavation costs outlined earlier and assuming one centrally located site, the estimated costs are as follows:

Excavation	$12,500,000
Transportation	$ 1,600,000
Construction & Waste Placement	$12,500,000
Total Estimated Cost	$26,600,000

Project time could be very flexible. Individual sites could be excavated at the rate of 1000 to 3000 cubic yards per day. The limiting factor would be at the central closure site. However, this site could be designed to handle 5,000-10,000 cubic yards per day. Based on these handling rates, the project culd be executed in 2-3 months at an estimated cost of approximately $50.00 per cubic yard.

The above ground closure approach obviously satisfies the economic, scale of operation and practical considerations.

Summary

In summary, Rollins Environmental Services (TX) Inc. recommends a land disposal/above ground closure methodology for the dioxin problem in Missouri because:

1. It places the dioxin contamination in a secure position, out of the public domain, within the fastest time frame,

2. present technologies of incineration and solvent extraction may create additional hazards due to multiple handling of the waste material, and

3. an above ground closure facility will insure secure storage of the dioxin waste until such time as a viable treatment method is developed (i.e., chemical or biological degradation).

IT Enviroscience

It Enviroscience (ITE), a division of It Corporation, has been engaged in dioxin decontamination and analysis activities for the last six years. We are familiar with the literature and much of the on-going research in this field. Also, we have expended considerable internal resources in testing destruction techniques in the laboratory and in evaluating various engineering concepts. We believe that there are several technically feasible dioxin treatment methods that have been proved in principle. These methods are thermal destruction, soil extraction and treatment of the extract, in-situ soil treatment, and soil stabilization.

ITE does not recommend any single treatment technology at this time but proposes technical evaluation for comparison purposes. After the final decision, IT is prepared to design and/or operate the disposal process.

Selection of the appropriate treatment technique for Missouri soil should await technical demonstration of the method. In this manner, important scientific, engineering, and economic parameters can be defined. In the proof-of-principle stage of any process, differences in engineering assumptions commonly lead to variations in cost estimates. Only after technology demonstrations in engineering scale equipment can appropriate comparisons be carried out.

Thermal oxidation evaluation requires two parts, an engineering study to define the ITE-cement kiln process, described below, and a demonstration of thermal destruction efficiency using the U.S. EPA mobile incinerator. The engineering study is estimated at $50,000 in 3 months, the demonstration burn at $1,000,000 within one year.

Technical demonstration of solvent extraction can be carried out for about $250,000 in 9 months, demonstration of in situ treatment can be provided for $100,000 to 250,000 in 9 months, and demonstration of soil stabilization for about $200,000 in 9 months.

ITE has facilities suitable for handling large quantities of dioxin and the personnel knowledgeable in dioxin chemistry, engineering, waste incineration, and plant operation. We propose an unbiased technology evaluation of processes that the Governor's Task Force wishes to pursue by weighing toxicological, technical, economic, and social factors.

Thermal Oxidation

At present, thermal oxidation of dioxin-contaminated soil has the highest probability of any process for achieving complete destruction of dioxin. Technical parameters that must be defined are the destruction and removal efficiency (DRE) for dioxin, which is a function of dioxin's stability and rate of volatilization from soil. Other important parameters are soil variability, handling, and feed rate to a rotary kiln. These and other questions must be addressed before the public will accept thermal destruction as an appropriate technology.

Suitable demonstration of this technique may be carried out by using the U.S. EPA's mobile incinerator.

Economics of thermal destruction depend on the equipment used for that purpose. A new rotary kiln incinerator, shown schematically in Fig. 1, can be designed and built within 2 to 4 years at a capital cost of about $7-20,000,000.

A potentially more economical solution involves modification of an existing cement kiln. Normal considerations for using cement kilns for hazardous waste destruction require adding a secondary combustion chamber, as in Fig. 1, and air pollution equipment to the cement kiln. Use of a secondary combustion chamber adds capital and large fuel costs to normal costs of operating a cement kiln. Fuel costs for such a facility range from \$50-200/ton of soil.

Cement kilns provide large residence times for solids at temperatures equivalent to those found in rotary kilns of hazardous waste incinerators. If dioxin-contaminated soil is introduced at the burner end of the cement kiln, there is adequate time to obtain burnout of dioxin at 2,000°F before the ash is dripped into the clinker cooler. The gases will be exposed to 2200°F for more than 2.2 seconds, normal requirements for destruction of PCB, a compound of similar stability as dioxin. This concept is illustrated in Fig. 2. The recycle of decontaminated soil is for purposes of heat and material balance and for gas cooling and cleaning.

If this ITE concept can be demonstrated and an existing kiln can be modified, low costs relative to other thermal processes can be achieved. This cost is presently estimated at \$180-300/ton based on the above concept. This figure includes fuel costs, equipment modifications, a rental fee, and other operating costs.

Extraction/Treatment

Extraction of dioxin-contaminated soil with appropriate solvents can remove dioxin from soil and allow concentration of dioxin in small quantities of extracts. The dioxin in these extracts can be destroyed by incineration, chemical treatment, or ultraviolet light irradiation.

Experiments by ITE show that three successive batch extractions using three volumes of solvent to one weight of soil reduces the dioxin concentration in soil from 360 ng/g to 4 ng/g, a reduction of greater than 98%. The third extract indicated <1 ng/g, residual dioxin in soil. However, rigorous Soxhlett extraction revealed the 4 ng/g residual concentration. These data confirm literature indications that a fraction of dioxin in soil is bound very tightly.

Important technical parameters that must be addressed are soil variability, selection of solvent, type of extraction equipment, phase separation, and solvent recovery. Estimated costs for a 100 ton/day fixed extraction/photolysis plant are \$150-300/ton These costs include excavation, 4-year depreciation of capital, maintenance, utilities, raw materials, labor, and miscellaneous items such as overhead, insurance, etc. Cost does not include final soil disposal.

A major concern about soil extraction is the ability to achieve residual dioxin levels of less than 1 ppb. If that level is unachievable for technical or economic reasons, is there value in reducing the concentration range of dioxin in soil to 1 to 10 ppb?

In Situ Treatment

Destruction of dioxin in soil without soil removal is attractive because there is no need for final soil disposal. Two techniques appear technically feasible.

The first, UV irradiation of soil sprayed with a solubilizing liquid, has been demonstrated at Seveso with sunlight (H. K. Wipf et al., in "Dioxin, Toxicological and Chemical Aspects," F. Cattabeni, A. Cavallaro, G. Galli, eds., Spectrum Publications, Inc., NY, 1978, p. 201-217). ITE is carring out experiments with synthetic UV light. The major questions are rate of reduction, degree of reduction, and environmental impact of reaction products.

If soil contamination is very deep, provisions must be made to plow up or excavate, disk, rake, and spread the soil. Preliminary cost estimates for in situ photo-chemical treatment are \$50-250/ton. This estimate includes capital depreciation, chemical, labor, and maintenance costs.

Chemical in-situ treatment is being explored by the U. S. EPA-Cincinnati. The proposed reaction involves displacement of chlorine atoms by alkali-metal alkoxides.

Soil Stabilization

Soil stabilization may be achieved by a number of proprietary procedures. The intent of these methods is to fix the dioxin and reduce its potential for migration. Since dioxin in soil does not appear to migrate, additional reduction in soil permeability and dioxin availability must be defined. At that point, decisions of relative risks and costs will decide the suitability of this procedure.

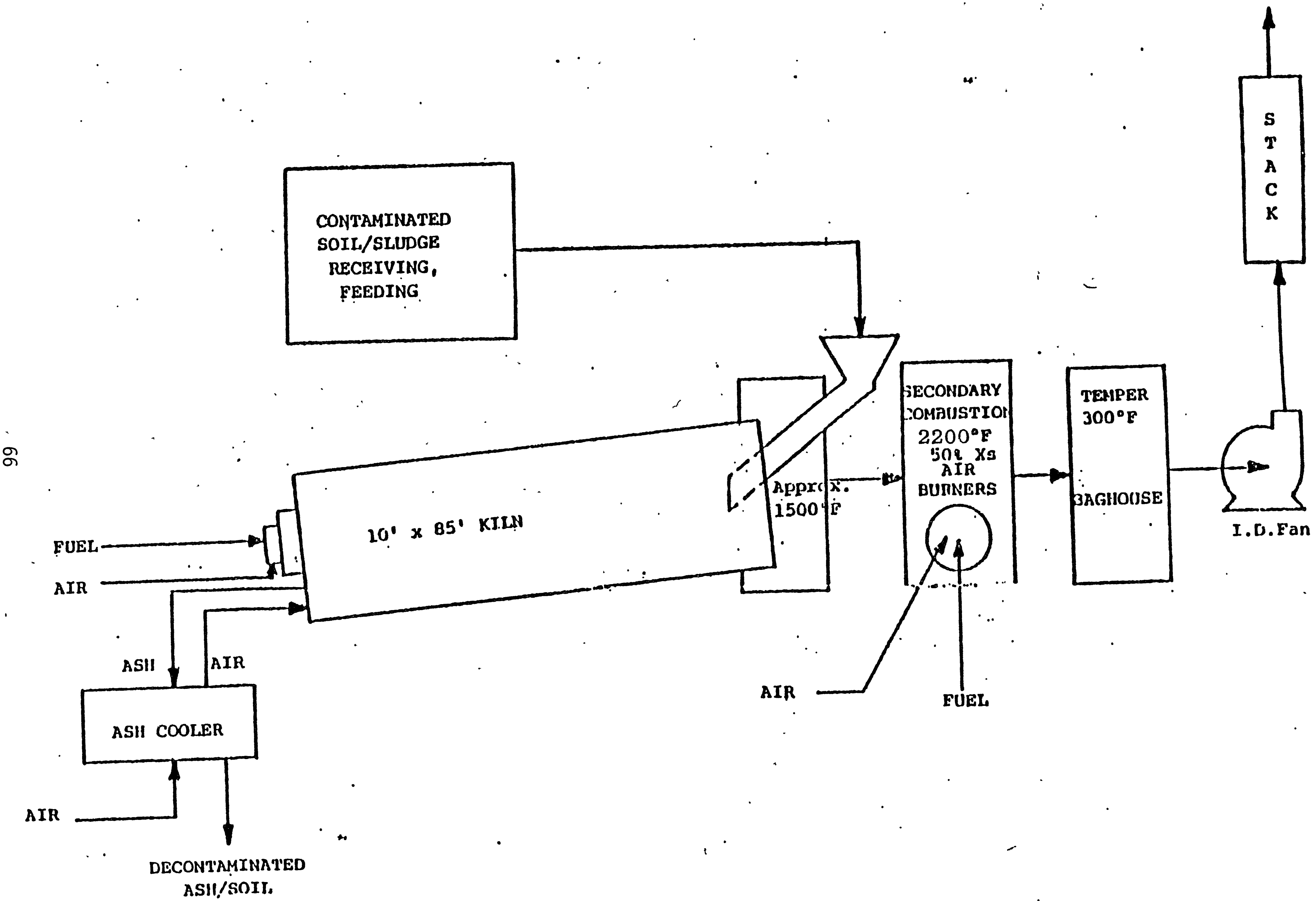

Fig. 1. New Rotary Kiln Thermal Oxidation System

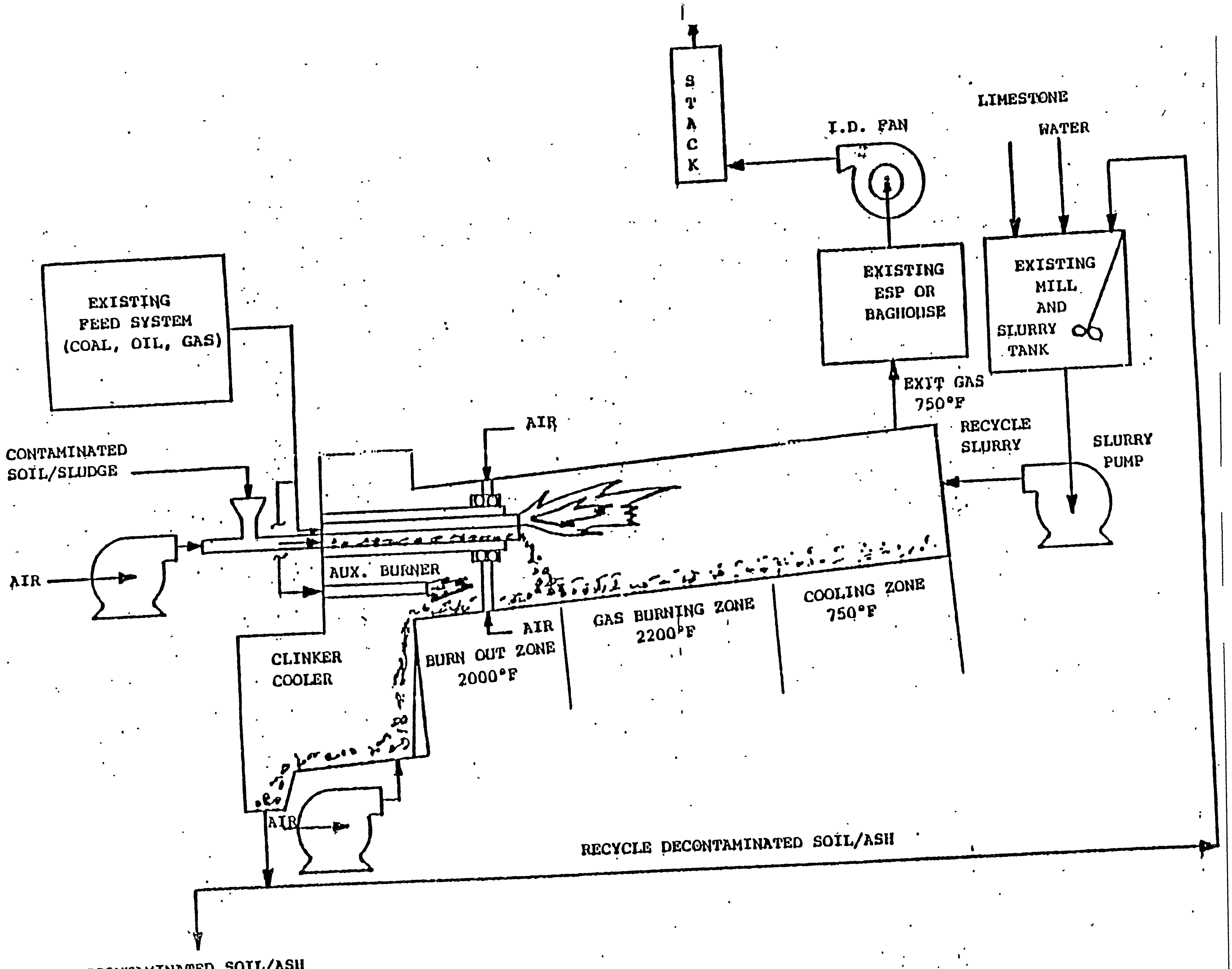

Fig. 2. Existing Cement Kiln System

CHAPTER 5

HEALTH RISK ASSESSMENT

The Division of Health and CDC have been working cooperatively from the early years of work with the dioxin issue and most intensively in the months since July 1982. The primary resource person at CDC has been Dr. Renate Kimbrough. Directly or indirectly, Dr. Kimbrough has been providing the guidance and the scientific aspects of health assessment. A preliminary health risk assessment was provided in December of 1982 to the Missouri Division of Health which concluded that levels greater than 1 ppb in soil pose an unacceptable health risk.

An expert group of consultants has been invited to discuss the theory and process of health risk assessment with CDC and a formal statement will be issued by CDC during the summer of 1983. The final report of the Task Force will have this new material for consideration or inclusion. The Task Force believes that the final health risk assessment methodology should be reserved for that report.

CHAPTER 6

ASSESSMENT OF AVAILABLE TECHNOLOGY

The purpose of this chapter is to provide an in-depth assessment of the various disposal technologies outlined in Chapter 3. Included are recommendations as to which disposal technologies are most likely to be viable and which ones require further study. It must be kept in mind that all of the technologies were described in Chapter 3 strictly on a descriptive basis, with no attempt at relative comparison. This chapter will evaluate those technologies on the basis of applicability to the specific sites, primarily Times Beach and Minker/Stout, and on practicality with respect to degree of development. It should be noted that, at this time, no technology has been demonstrated to destroy dioxin in soil to levels significantly below 1 ppb.

Currently Available Technologies

Following is an assessment of those technologies in which the Task Force considers the process or method of disposal to be available on a commercial scale, and deemed potentially capable of either detoxifying the dioxin contaminated soil, or preventing the release of the contaminant to the environment.

Incineration is considered to be the technology which probably offers a relatively short term permanent solution for dioxin contaminated soil. While data demonstrating destruction to sub-ppb levels is not yet available, it would appear that selection of proper temperatures and residence times would provide a reliable system for detoxification. As with all methods of destruction, it becomes practical only if EPA regulations will permit the treated soil to be treated as non-hazardous waste. Incineration of hazardous waste is common, equipment is commercially available, and controls to ensure environmental safety are well understood. It is recommended that trial burns, in facilities described below, should be made as soon as possible to demonstrate feasibility.

The EPA has at least two facilities which would be capable of performing the required trial burn. One is their mobile incineration system, which would be brought in and set up directly on the chosen site. Several problems exist with this approach, primarily because of the length of time it would take to set up the unit and arrange the necessary permits. Siting requirements such as electricity, water, and fuel would be difficult and expensive to set up. The mobile incineration unit is not recommended as a means of conducting the test burn, nor is it recommended as an end solution to the problem.

The second EPA facility is the newly constructed Pine Bluff incineration system in Arkansas. This incinerator is designated as a research facility, and has recently been granted the necessary permits to operate. It is understood that this unit would be capable of conducting a test burn for dioxin destruction. It is recommended that an attempt be made to obtain the highest priority on the test list for the facility and, once placed on list, all necessary research permits be expedited.

The Task Force believes that information resulting from the test burns, using various soils having different concentrations of contamination, will be useful in determining the degree of dioxin destruction that incineration can provide, and the residual dioxin left in the resultant ash. This data would permit negotiation with EPA as to whether this ash must be landfilled as a hazardous waste, or can be considered a non-hazardous material.

Ultra violet destruction of dioxin has been demonstrated in certain applications on a commercial scale. However, it has also been demonstrated that irradiation time becomes excessive as concentration of dioxin decreases into the ppb range. Therefore, it is not considered to be a viable solution to the problem of dioxin in soil at low concentrations, but may be useful in destroying dioxin in extracts.

Solvent extraction followed by incineration or other methods of destruction remains a possible solution to removal of dioxin from soil. Exhaustive continuous extraction is used in laboratory analysis of dioxin in soil. However, large scale extractions would probably require batch treatment with each stage of extraction removing a fixed fraction of the remaining dioxin, presenting the same problem as UV destruction as concentration of dioxin decreases. It is recommended that further study be done, and this technology is discussed further on page 71.

In place stabilization using grout curtains and organic or inorganic fixatives may be an acceptable final solution for some Missouri sites, but is not recommended for the Times Beach and Minker/Stout sites for the following reasons. In the case of the Minker/Stout site, the geology of the site is poorly suited to this type of containment effort. A layer of highly fractured limestone above sandstone makes complete elimination of groundwater movement through the contaminated area difficult to guarantee. In the case of Times Beach, the contamination is predominantly on and along the roads. But in order to ensure containment of the contaminated soil, the entire town would have to be encircled by the grout curtain, making this an inefficient means of containment. However, the concept of grout curtain containment is in use today, and may be a viable alternative at sites other than Times Beach and Minker/Stout, depending on site specific geology.

Although organic and inorganic fixatives are considered methods of in place stabilization, further study is needed. These methods will be discussed in further detail on page 71.

On-site storage, either in below ground cells or above ground vaults, was evaluated. Below ground cells do not provide an appropriate option. This option would involve on-site excavation and subsequent reburial of the contaminated soil as well as long term monitoring at each of the sites.

Above ground concrete storage vaults have some advantages over below ground storage in that monitoring requirements are more easily met, and any leaks or faults in the structure are more easily detected and repaired. This is not a recommended option, except under special circumstances, because of logistical problems in permitting, monitoring and maintaining 30 or more individual sites. Special circumstances, as mentioned above, could involve the consolidation and storage of contaminated soils from a number of smaller sites at one of the larger, centrally located sites in the area, probably as interim storage in conjunction with a treatment scheme.

The Task Force discussed the possibility of transport to a secure landfill offsite as a remedial action for the Times Beach and Minker/Stout sites. There are existing outstate landfills which could possibly be considered, but landfilling at any of them is not a viable option at this time, due to the large volumes of soil involved, and the distance that this volume of soil would have to be transported. The Task Force wishes to emphasize that landfilling in this manner should only be considered as a last resort for these sites, if all other options for remedial action have failed.

The final option which seemed to be viable was that of in place treatment of the contaminated soil. Most of the technologies grouped into this option are still in the developmental stages, and will be discussed on page 72.

Implementation Considerations

The Task Force believes that in order to implement many of the above mentioned technologies, a centrally-located hazardous waste storage-treatment facility should be considered. A study should be done to resolve where such a facility could be located and whether it should be state owned.

Recommendations for Further Study

Certain of the technologies discussed in Chapter 3 are considered to have merit, but have not been developed to the point where they can be considered viable disposal techniques. Some are functioning at lab scale. Some are operating commercially for wastes other than dioxins, and some have not yet been tested. However, each of these technologies is worth pursuing. Further research and testing should be done on each of the following technologies.

Fixatives

Under the option of in place stabilization, two types of surface fixatives exist: inorganic substances and organic polymers. Further studies on impermeability and long-term stability of these types of fixatives should be conducted.

Solvent Extraction

The concept of solvent extraction is well established and in wide use. However, the feasibility of this process to remove dioxin from contaminated soils to sub-ppb levels has yet to be demonstrated. In an effort to determine if solvent extraction can reduce the level of contamination to environmentally acceptable levels, the following studies are recommended.

An appropriate solvent should be identified. The ideal solvent must have a large solubility for dioxin and a large solvent-soil distribution coefficient, must be easily removable from the soil, and must be non-toxic because a portion of the solvent will probably remain trapped with the soil even after drying. The solvent studies should include supercritical fluids as well as more common solvents.

Additional studies should address the destruction of dioxin in the solvent after the extraction process is completed. Some of the methods which have been proposed are destruction by the addition of a chemical reagent, incineration of the solvent, and destruction of the dioxin using UV photolysis.

In-Place Treatment

The option of in-place treatment is important if a method of decontamination can be developed whereby the contaminated soil would not need to be excavated or moved. In-place treatment offers the advantage of minimal risk to workers and the environment and probably would be the least expensive method. Specific study of the following forms of in-place treatment is recommended.

Biodegradation is already in use on a commercial scale for the detoxification of certain wastes. However, researchers have not yet been able to isolate or genetically engineer organisms which are capable of degrading dioxin. The possibility also exists that an organism may be found which can metabolize dioxin in a controlled environment, in which case the contaminated soil could be excavated and placed in the controlled environment. This research is of the utmost importance and should continue.

Other methods of in-place treatment which merit further study are ionizing radiation, chemical treatment, and any other method which shows possibility of destroying or stabilizing the dioxin molecule.

Recognizing that the methods listed above may not be the only ones which should be considered as possible future options for remedial action, the Task Force welcomes and encourages any new technology which holds the promise of solving Missouri's dioxin problems.

CHAPTER 7

RECOMMENDATIONS FOR FURTHER RESEARCH

This chapter attempts to focus on research needs which are necessary to make informed decisions about remedial action. The two major areas of concern in which data is lacking are health studies and the behavior of dioxin in the environment.

Many animal studies have been done which indicate that widely varying levels of toxicity demonstrated by different animal species. Much debate has been heard on how to extrapolate the animal studies on toxicity to humans. Research on humans has not clearly indicated what level of exposure can cause toxic effects.

Research and accidental exposure of humans has shown definite acute effects of dioxin such as chloracne, liver disease and porphyria cutanea tarda. Birth defects have been reported in some studies but not confirmed in others. Long term effects such as cancer are still debatable, although limited data on soft tissue sarcomas are suggestive. Therefore, continuing research on the human effects of dioxin is recommended.

A related issue is that of the health of residents who have lived at contaminated sites for a number of years. Since many questions remain about the long term health effects that dioxin may have on these people, the Task Force recommends consideration of continued and broadened health studies be conducted on these people.

Further studies on the behavior of dioxin in the environment are needed. Research should be conducted to determine the possibility of dioxin leaching from contaminated soil into groundwater over a period of years. Related work is necessary to determine if dioxin found in aquatic organisms in surface waters near contaminated sites is due to leaching of dioxin directly into surface waters, or to the transport of contaminated soils as sediment into the water. Since the presence of dioxin has been impossible to detect in water, some type of concentrator should be developed, such as a resin or charcoal, or a quantitative bioindicator. Further research into background levels of dioxin in aquatic organisms of surface waters away from the contaminated sites is recommended.

Research should be conducted regarding the persistence of dioxin in the environment, particularly as a contaminant in soil. The use of the term "half life" with respect to dioxin in the environment is erroneous, and a systematic attempt should be made to clarify the mechanisms of dioxin disappearance in the environment.

Possibly the most important topic for additional study is that of the bioavailability of dioxin in soil. Research data available has indicated that dioxin in soil exhibits a binding phenomena, in that the dioxin molecules adhere very tightly to the soil particles. Further research may indicate whether or not the dioxin is so tightly bound to the soil that it is not available to the organism that comes in contact with the soil, whether that contact is dermal or by ingestion.

The Task Force recognizes the need for research and resources to help solve the problems that Missouri faces. This research also will assist in addressing and solving national problems. There already exists in Missouri the necessary expertise and research facilities that could be equipped to perform the necessary studies, if properly funded.

CHAPTER 8

SPECIFIC SITE RECOMMENDATIONS

This chapter deals with recommendations of the Task Force for the Times Beach and Minker/Stout sites, the two sites which have had the highest priority. The Task Force will submit recommendations for other sites in its final report. Certain of the comments to follow are general in nature, and could be applied to both Times Beach and Minker/Stout. These comments will be addressed first. Comments more specific to the individual sites will be discussed in separate sections.

Although one cannot be absolutely sure what actual exposure or risk is experienced by any individual Missouri citizen, the public health recommendations of separating the people from the soil contaminated with greater than 1 ppb appear to be reasonable and prudent measures. It must also be assured that the sites themselves are stable and that no significant movement of either dioxin or contaminated soil is occurring. Actions already taken at the two sites, namely the temporary relocation and buyout, will serve to alleviate one of the main concerns of the Task Force, namely human exposure at the sites. These measures have provided more time to study the remedial actions and to make informed decisions about those remedial actions. It is of prime importance that the buyout be expedited. Once that is accomplished, the Task Force recommends that access to the sites be completely restricted by posting signs, erecting barriers, and any other measures necessary to keep unauthorized persons away from the contaminated soil. This would come under the heading of <u>initial remedial action</u>.

The Task Force recommends a program of <u>additional sampling</u> to determine the nature and extent of the problem. This sampling should include both surface water and ground water monitoring to determine whether the contamination is migrating, either by direct leaching from the soil, or by sediment transport. A concentrator such as charcoal, resin, or a quantitative bioindicator, should be used to detect any low levels of dioxin in the water.

In studying the information available about the two sites, the Task Force concludes that the Minker/Stout site needs priority over Times Beach, at least in implementing initial remedial action, because Minker/Stout is an unstable site with respect to migration of contaminated soils whereas Times Beach appears to be more stable. These concerns are addressed in greater detail in the following sections.

The adequacy of the health studies performed to date should be evaluated.

Minker/Stout

The Task Force recommends that the buyout for Minker/Stout be expedited. Information indicates that this site is unstable with respect to migration of soils, hence the priority status for Minker/Stout. Immediate action should be taken to stop the erosion which is occurring in the fill area and washing across the site into Romaine Creek. Short term measures such as extending the drain pipe out from the culvert and past the fill area, along with covering eroded areas with sod or other natural cover may be sufficient to

stop most or all of the erosion of contaminated soil from the fill area. Thereafter, monitoring of surface and groundwater should be done in the site area to determine if erosion of contaminated soil has been eliminated.

While the short term measures outlined above should reduce soil erosion, the site must still be considered an unstable one because of extremely poor site geology, consisting of a layer of highly fractured limestone over sandstone. The Task Force recommends that planning for final remedial action for this site be continued with all deliberate speed.

Times Beach

The buyout should be expedited in order to remove the residents from the site and reduce exposure to the contaminated soil. Access to the site should then be limited to further reduce exposure. Evidence indicates that Times Beach is a relatively stable site. Therefore, no further immediate remedial actions are recommended at this time. The Task Force recommends that additional soil sampling be done to determine more specifically the areas and levels of contamination within the site. Sampling of surface and groundwater should be done to determine if the contamination is spreading due to leaching or sediment transport. If the results of these studies should indicate that significant contaminant migration is occurring, then additional interim remedial action should be undertaken. In any event, the results of the sampling can be used to aid in planning for final remedial action at the site.

APPENDICES

APPENDIX 1

AGENDA

DIOXIN TASK FORCE MEETING

February 23, 1983

Conference Room, Department of Natural Resources
1915 Southridge
Jefferson City, Missouri

1.	10:00	Introduction of Task Force Members........Fred Lafser, DNR Governor's Remarks to Task Force
2.	10:30	Discussion, Scope and Magnitude of Dioxin Problems in Missouri:
		(a) Location and Levels of Contamination......Fred Lafser, DNR
		(b) Health Effects......Robert Hotchkiss, DOH
	12:00	Lunch
3.	1:30	Summary of Solutions Proposed by Interested Companies......DNR Staff
4.	1:45	EPA Role
5.	2:15	Discussion of Task Force Activities and Assignment of Sub-Tasks
6.	3:00	Discussion of Schedule of Meetings
7.	3:15	Adjourn

DIOXIN TASK FORCE SITE TOUR 3-17-83

ITINERARY

8:00 a.m.	Arrive - lobby of Airport Marriott
8:15 a.m.	Leave Marriott
9:00 a.m.	Arrive at Shenadoah Stables
9:30 a.m.	Leave Shenadoah Stables
10:30 a.m.	Arrive at Methodist Church (drive by)
11:00 a.m.	Arrive at Times Beach
11:45 a.m.	Leave Times Beach
12:00-1:30 p.m.	Lunch at Stratford House - Fenton
2:00 p.m.	Bubbling Springs Stables (drive by) (Cashel Site)
2:15 p.m.	Arrive Minker & Stout Sites (Sullens Site)
3:00 p.m.	Leave Minker & Stout Sites
3:30 p.m.	Jones Truck Lines (drive by)
3:40 p.m.	Overnite Transfer, Inc. (drive by)
4:00 p.m.	Southern Cross Lumber (drive by)
4:30 p.m.	Return to Marriott parking lot

A G E N D A
(Revised)

DIOXIN TASK FORCE MEETING

March 30, 1983

Conference Room, Department of Natural Resources
1915 Southridge
Jefferson City, Missouri

1.	10:00	Approval of previous meeting minutes....February 23 Meeting
2.	10:15	Explanation of Cattle Deaths on Bill Davis Farm....Dr. Thomas Satalowich, DVM
3.	10:30	Evaluation of Dioxin Disposal Technologies and Costs....CH_2M - Greg Peterson, John W. Lee, Bill Byers
	1:00	Lunch
4.	2:00	Discussion of Superfund Procedures - EPA
5.	3:00	Summary of proposals received to date by the Waste Management Program from firms interested in dioxin cleanup....Beth Rice, WMP
6.	5:00	Future Meeting Agendas....April 14 and 28 meetings
7.	5:30	Adjourn

AGENDA
(Revised)
DIOXIN TASK FORCE MEETING

April 13, 1983

Second Floor Conference Room
Division of Health-Laboratory Building
307 West McCarty
Jefferson City, Missouri

1. 3:00 - VIDEO TAPE SERIES

Tape 1
"Introductory Discussion of Dioxin Problem in Missouri"
by Henry Falk, M.D., CDC, Atlanta, Georgia

Tape 2
"Animal and Human Health Effects of 2,3,7,8 Tetrachlorodibenzo Dioxin - An Overview"
by Renate Kimbrough, M.D., CDC, Atlanta, Georgia

2. 5:00 - Dinner

Conclusion of Video Tape Series (Optional)

April 14, 1983

Department of Natural Resources Conference Room
1915 Southridge Drive
Jefferson City, Missouri

1. Approval of previous meeting minutes....March 30 meeting

2. 8:30 - William G. Dunagin, M.D.
Division of Dermatology M173
University of Missouri
Health Science Center
Columbia, Missouri 65212

3. 10:00 - Jay Murray, Ph.D.
Syntex Corporation
3401 Hillview Avenue
Palo Alto, California 94304

4. 11:00 - David Stallings, Ph.D.
Chief Chemist
Columbia National Fisheries Research Lab
U.S. Fish and Wildlife Service
Route 1
Columbia, Missouri 65201

5. 12:00 - Lunch

6. 1:30 - Alvin L. Young, Ph.D.
Major, U.S. Air Force
Acting Chief of Research Section
Agent Orange Project Office
810 Vermont Ave., N.W.
Washington, D.C. 20420

7. 3:00 - Dr. Robert Neal, President
Chemical Industry Institute of Toxicology
Research Triangle Park
Raleigh-Durham, North Carolina 27709

8. 4:00 - Stephen M. Ayres, M.D.
Department of Internal Medicine
St. Louis University Medical School
1325 South Grand Boulevard
St. Louis, Missouri 63104

9. 5:00 - Future Meeting Agendas....April 28 and May 12 Meetings

10. 5:15 - Adjourn

A G E N D A

DIOXIN TASK FORCE MEETING

April 28, 1983

Department of Natural Resources Conference Room
1915 Southridge Drive
Jefferson City, Missouri

I. 9:00 a.m. Appoval of previous meeting minutes...March 30 and April 14 meetings

II. 9:15 a.m. Speakers:

(1)	Phillip C. Kearney, Ph.D. Chief, Pesticide Degradation Lab Agricultural Environmental Quality Inst. Agricultural Research Center, USDA Beltsville, Maryland	Fate of dioxin in the environment; plant, fish and animal studies
(2)	Jurgen H. Exner, Ph.D. Manager, Engineering/Research and Development IT Enviroscience Knoxville, Tennessee	Behavior of dioxin in soils-degradation
(3)	Henry Falk, M.D. Chief, Special Studies Branch Chronic Disease Division Center for Environmental Health Centers for Disease Control Atlanta, Georgia	Human health effects of dioxin

III. 12:00 Lunch - catered in by Nick's Homestead

IV. 1:00 p.m. Slide presentation/discussion of southwest sites:
(1) Neosho site - Dwight Douglas
(2) Denny Farm site - Ray Forrester
(3) Spring River - Ron Crunkilton
Dr. Jim Whitley
Department of Conservation

V. 2:30 p.m. Discussion with EPA Representative
(1) New RCRA rule on dioxin
(2) Coordination with CH2M-Hill feasibility study

VI. 3:00 p.m. Discussion of interim report due June 1, 1983

VII. 5:00 p.m. Future meeting agendas...May 12 and May 26 meetings

VIII. 5:30 p.m. Adjourn

TENTATIVE AGENDA

DIOXIN TASK FORCE MEETING

May 12, 1983

Ramada Inn - Roanoke Room
1510 Jefferson Street
Jefferson City, Missouri

I. 9:00 a.m. Approval of minutes...April 28 meeting

II. 9:15 a.m. Presentations by firms submitting preliminary remedial action proposals

(1). Midland Ross Corporation 2375 Dorr Street Toledo, Ohio	incineration
(2). Chemical Waste Management Waste Management, Inc. 3003 Butterfield Road Oak Brook, Illinois	extraction, incineration of solvent, landfilling of soil
(3). Critical Fluids Systems, Inc. Subsidiary, Arthur D. Little, Inc. 25 Acorn Park Cambridge, Mass.	extraction by supercritical solvent
15 Minute Break	
(4). Acurex Waste Technologies, Inc. Subsidiary, Acurex Corp. 8074 Beechmont Avenue Cincinnati, Ohio	extraction, chemical treatment of solvent
(5). SCA Chemical Services, Inc. 1836 North Broadway St. Louis, Missouri	SCA doesn't wish to make a presentation at this time, but would like to make themselves available to answer questions about their proposal

12:00 Lunch to be arranged by Ramada Inn

II. 1:00 p.m. (Continued)

(6). IT Enviroscience 312 Directors Drive Knoxville, Tennessee	thermal destruction; extraction; in situ treatment
(7) Rollins Environmental Services, Inc. P. O. Box 609 Deer Park, Texas	comparison of incineration, extraction, and landfilling

III. 2:00 p.m. Discussion of Initial Draft Interim Report

3:00 p.m. 15 Minute Break

IV. 5:00 p.m. Adjourn

May 13, 1983

I. 9:00 a.m. Further Discussion of Initial Draft Interim Report

10:30 a.m. 15 Minute break

12:00 p.m. Lunch to be arranged by Ramada Inn

II. 1:00 p.m. Further Discussion of Initial Draft Interim Report

III. 4:00 p.m. Future meeting agendas...May 26 and June 16 meetings

IV. 4:30 p.m. Adjourn

AGENDA

DIOXIN TASK FORCE MEETING

May 26, 1983
Department of Natural Resources
Conference Room
1915 Southridge Drive
Jefferson City, Missouri

I.	9:00 a.m.	Approval of Previous Meeting Minutes...May 12 and 13 Meeting
II.	9:15 a.m.	Discussion of Final Draft Interim Report
III.	10:30 a.m.	15 Minute Break
IV.	11:45 a.m.	Lunch at Nicks Homestead
V.	1:00 p.m.	Renate Kimbrough, MD. Medical Officer Center of Environmental Health Centers for Disease Control Atlanta, Ga. — Health risk assessments
VI.	2:30 p.m.	Further Discussion of Final Draft Interim Report
VII.	4:30 p.m.	Discussion of Proposed RCRA Rule on Dioxin
VIII.	5:00 p.m.	Future Meeting Agendas...June 16 Meeting
IX.	5:30 p.m.	Adjourn

APPENDIX II

DIOXIN TASK FORCE MEETING

February 23, 1983

Department of Natural Resources' Conference Room
Jefferson City, Missouri

MEMBERS PRESENT

James Finch, Chairman
Dwight Douglas
Ray Forrester
Perry King
Carl Marienfeld
Sharon Rogers
George Roush
James Shaddy
Betty Wilson

Robert Powell was not present. Claudia Spener represented Dr. Powell.

ORDER OF BUSINESS

The meeting came to order at 10:10 a.m.

Missouri Department of Natural Resources' Director, Fred Lafser, introduced each Dioxin Task Force member. He also introduced Dr. Robert Hotchkiss, Division of Health; Bill Rice, U.S. Environmental Protection Agency; and several DNR staff members.

Governor Christopher S. Bond then welcomed the task force members and thanked them for serving on the task force. Governor Bond presented some background information on what has happened and various steps taken by him since the dioxin issue began last year. The Governor directed the task force to study all angles of the problem and to study any alternatives for eliminating the danger of dioxin and to recommend the most safe, practical and technologically sound solutions. He also presented a five-point dioxin program which he has recommended to the Missouri General Assembly (please refer to the transcript of the Governor's remarks previously sent to you).

Dr. David Bedan, Director of the Waste Management Program, then gave a brief history of the contamination episode. He presented a chart, produced by EPA, that showed the origination of the waste from the old NEPACCO plant in Verona, Missouri and showed how the waste got to the different sites. Dr. Bedan then presented a map of the 22 confirmed sites and gave a brief summary description of each site. He noted there were three errors in the summary description.

1. Minker Site - The range of concentration should be from .3-300 ppb instead of 900 ppb.

2. Times Beach Site - It should be 300 ppb instead of 100 ppb.

3. IML Lines Site - This should be changed to the Overnite Transfer Company.

Dr. Robert Hotchkiss, Director of the Division of Health, then provided a summary of the health effects that dioxin has had on experimental animals and situations of human exposure. He also provided a summary of different studies relating to the cancer-causing potential of human exposure to dioxin. He stated there is a study of the possible health effects associated with the actual real exposure to dioxin here in Missouri that is in the process of being carried out. There have been 146 dermatological exams, 112 comprehensive medical exams, and over 850 extensive medical questionnaires involved in this study.

Dr. Denny Donnell, also of the Division of Health, summarized a talk given by Dr. Marilyn Fingerhut to the physicians at the St. Louis Medical Society which referred to Swedish and American studies concerning questions of the cancer-causing potential of human exposure to dioxin.

Representative Bob Feigenbaum then discussed three bills that have come out of public hearings and meetings held since October. One of the bills is the Superfund which would provide funding in the amount of $6.8 million for an ongoing cleanup measure, not only for the dioxin sites but also for future hazardous waste cleanups. Of the $6.8 million, $5 million would come from generators, $1.5 million from transporters, and the remainder from landfill operators. This Superfund money would only be used when the responsible party could not be found. The second bill is the Cancer Registry which will allow the state to correlate any high levels of different types of cancer to the hazardous waste sites. This information could then be used to convince EPA and federal agencies that there is a problem at a particular site. The third bill is the Workers' Right to Know which doesn't deal just with the dioxin problem.

Joe Jansen of the Waste Management Program then gave a summary of some of the disposal methods and proposals that the department has received from various companies in the waste management business indicating their desire to help with the dioxin problem. Mr. Jansen then presented a chart which gave some very preliminary and very general cost estimates of the different alternatives that the department thinks might work for clean up at the various sites. These were very rough estimates.

Bill Rice, U.S. Environmental Protection Agency, then discussed EPA's role and activities with the dioxin problem. First EPA or the Missouri Department of Natural Resources investigates the sites to determine whether there is a likelihood that dioxin is present. They would send out sampling teams and have the samples analyzed either through their own laboratories or through contracted laboratories. They would then decide from this initial sampling if additional sampling is required. After the problem has been characterized, they can then take legal action against property owners or companies may propose to clean up the site themselves or the sites can be put on the National Priority List.

FUTURE MEETINGS

It was decided that the next meeting would include visits to some of the dioxin sites in the St. Louis area. The task force members are to meet in the lobby of the airport Marriott at 8:00 a.m. on Thursday, March 17. From there they would travel by bus to various dioxin sites in the area. After this trip it would then be decided whether trips to sites in southwestern Missouri would be beneficial.

The following meeting dates were also decided upon:

- Wednesday, March 30
- Thursday, April 14
- Thursday, April 28
- Thursday, May 12
- Thursday, May 26

These meetings will be held in the Department of Natural Resources' conference room and will begin at 9:00 a.m. and run until 4:00 p.m. with an hour for lunch from 12:00 to 1:00.

OTHER BUSINESS

There was some discussion on task force activities and assignment of sub-tasks. It was suggested that after the site visits and gathering of some background information on various sites that an attempt be made to group the sites by some criteria and prioritize them for the first report and have various people work on various aspects (landfilling, incineration, health sub-task, disposal sub-task). It was suggested that the members think about this and give suggestions on who would be particularly desirable and set up sub-tasks at the next meeting.

Joe Jansen then distributed expense account forms and explained to the members how to fill out the forms for reimbursement.

Some suggestions were then made on various speakers to hear at future task force meetings. It was decided that the members should write DNR about any suggestions they have and have the department make arrangements for the speakers. The contact person is to be Dr. David Bedan, Department of Natural Resources, Waste Management Program, P.O. Box 1368, Jefferson City, MO 65102 (phone: 314-751-3241). Regarding speakers on health related issues the contact person is to be Dr. Denny Donnell, Department of Social Services, Division of Health, P.O. Box 570, Jefferson City, MO 65102 (phone: 314-751-2713).

The meeting was adjourned at 3:35 p.m.

Respectfully submitted,

Dianne Luebbert

Dianne Luebbert
Secretary

Approved,

James A. Finch Jr.

James Finch
Chairman

April 1, 1983

Date

DIOXIN TASK FORCE MEETING

March 30, 1983

Department of Natural Resources' Conference Room
Jefferson City, Missouri

MEMBERS PRESENT

James Finch, Chairman
Dwight Douglas
Ray Forrester
Perry King
Carl Marienfeld
Robert Powell
Sharon Rogers
George Roush
James Shaddy
Betty Wilson

ORDER OF BUSINESS

The meeting was called to order at 10:00 a.m.

There was a correction to the February 23, 1983 minutes. Where the Minker Site and Times Beach Site were listed at the bottom of page 1, ppm should have been ppb. Dwight Douglas then made a motion to approve the minutes with corrections. They were approved.

Dr. Thomas Satalowich, DVM, Missouri Division of Health, discussed the analyses of the cattle deaths on the Bill Davis farm. He stated the milk had been tested for dioxin approximately four times and turned out negative each time. Mr. Davis also had brought cattle that had died on his farm to the lab to be tested, and these tests also turned out negative. The cattle had a form of infectious bovine leukemia that could not be detected as dioxin related.

Mr. Robert Morby, U.S. Environmental Protection Agency, then discussed Superfund procedures. He discussed the three principal types of action: immediate removal, planned removal, and remedial action. He also discussed the difference between Cooperative Agreement and State Contract.

David Bedan then briefly talked about the "Report on Potential and Confirmed Uncontrolled Hazardous Waste Sites in Missouri" that had been released the previous day, March 29.

Dr. Denny Donnell, Missouri Division of Health, discussed the tentative plan for speakers for the April 14, 1983 meeting. The five speakers that are available are:

1. Bill Dunagin - UMC Dermatologist
2. Jay Murray - Syntex, Palo Alto, California
3. Alvin Young - Veteran's Administration, Washington, D.C.
4. Robert Neal - Chemical Industrial Institute of Toxicology, North Carolina
5. Stephen Ayres - Chief of Internal Medicine, St. Louis University Hospital

Some of the other suggested speakers who could not come until a later date or could not come at all are:

1. Samuel Epstein - University of Illinois at Chicago - Is not willing to come.
2. Ellen Silbergeld - Environmental Defense Fund, Washington, D.C. - Would be available on April 27 or 28.
3. Ray Susskind - Institute of Environmental Health, University of Cincinnati - Would not be available until early July.
4. Dr. Kimbrough - CDC - Would not be available for several weeks.

Dr. Donnell suggested the Task Force might want to see the video tapes of presentations to the St. Louis Medical Society, including a talk given by Dr. Marilyn Fingerhut concerning questions of the cancer-causing potential of human exposure to dioxin.

It was then suggested that the Task Force view the video tapes on the afternoon of April 13 starting at 3:00, breaking for dinner around 5:00 or 5:30, and reconvening again in the evening around 7:30 or 8:00 p.m.

Greg Peterson and Bill Byers from CH_2M Hill then gave a presentation on the evaluation of dioxin disposal technologies and costs for the Minker/Stout Site. They discussed the advantages and disadvantages of six different options. The six options are:

1. Securing in place
2. Consolidation on site
3. Securing off site
4. Incineration
5. Extraction
6. Storage until new technology is developed.

Beth Rice, Waste Management Program, then gave a summary of the proposals received to date by the Waste Management Program from firms interested in dioxin cleanup. Preliminary proposals were requested from all the firms that contacted us. At the present time the program has received two proposals.

A sixth person was then added to the list of speakers for April 14. Dr. Carnow of the University of Illinois at Chicago will be speaking for Dr. Epstein. It was decided since there would be a sixth speaker to start the April 14 meeting at 8:30 a.m. with three speakers in the morning and three in the afternoon. There would be an hour for task force discussion at the end of the day.

Some suggestions were made by Dave Bedan and Robert Schreiber for topics for the April 28 meeting:

1. Presentations from companies interested in dioxin cleanup.
2. Presentations from labs involved in testing for dioxin.
3. Presentations from people involved in studies concerning the effects of dioxin on animals
4. Someone from Fish & Wildlife Research Center in Columbia.

There was then some discussion on whether the Task Force should hear from specific companies about their proposals.

Dwight Douglas then questioned whether the Task Force wanted to see the video presentation from the wastewater school at Neosho. It was decided to see these slides and video presentation at the April 28 meeting. The Task Force would then decide whether they should visit the sites in southwestern Missouri, since complaints had been received saying the dioxin problem was being addressed more in the St. Louis area than in the southwestern Missouri area.

The meeting was adjourned at 4:20 p.m.

Respectfully submitted,

Dianne Luebbert
Dianne Luebbert
Secretary

Approved,

James A. Finch
James Finch
Chairman

4/28/82
Date

DIOXIN TASK FORCE MEETING

April 14, 1983

Department of Natural Resources' Conference Room
Jefferson City, Missouri

MEMBERS PRESENT

James Finch, Chairman
Dwight Douglas
Ray Forrester
Perry King
Carl Marienfeld
Robert Powell
Sharon Rogers
George Roush
James Shaddy
Betty Wilson

ORDER OF BUSINESS

The Task Force met the previous afternoon, April 13, 1983, at 3:00 p.m. at the Division of Health Laboratory Building to view three video tapes. One of the tapes was titled "Introductory Discussion of Dioxin Problem in Missouri" by Henry Falk, M.D., CDC, Atlanta, Georgia. The second tape was titled "Animal and Human Health Effects of 2,3,7,8 Tetrachlorodibenzo Dioxin - An Overview" by Renate Kimbrough, M.D., CDC, Atlanta, Georgia. The third tape was titled "Epidemiology of Sarcomas" by Marilyn Fingerhut, Ph.D.

The meeting on April 14 was called to order at 8:40 a.m. at the Department of Natural Resources.

The first speaker was Dr. William G. Dunagin, M.D., Division of Dermatology, University of Missouri Health Science Center, Columbia, Missouri. Dr. Dunagin made the following conclusions:

1. Chloracne is the most sensitive indicator of dioxin exposure in humans.

2. There do not appear to be any cases of chloracne in Missouri.

3. Dermal absorption of dioxin from soil in Missouri is about one million times less than the amount necessary to induce toxicity.

4. In animal studies the dose of dioxin necessary to cause cancer is near or about the same dose which causes direct toxicity.

The next speaker was Dr. Jay Murray, Ph.D., Syntex Corporation, Palo Alto, California. Dr. Murray discussed some of the reproductive and other toxic effects of dioxin seen in laboratory animals. He also summarized some of the

human health effects of dioxin including chloracne, liver effects, neuromuscular symptoms, altered porphyrin metabolism, and a number of subjective symptoms. Dr. Murray also discussed a study of an industrial accident that occurred at a Monsanto Plant in 1949 involving overexposure to TCDD and another industrial accident that occurred in Seveso, Italy.

The next speaker was Dr. David Stalling, Ph.D., Chief Chemist, Columbia National Fisheries Research Lab, U.S. Fish and Wildlife Service, Columbia, Missouri. Dr. Stalling summarized some of the work being done in various parts of the country on analysis for dioxin. He also discussed dibenzofurans which are very similar in structure and behavior to dioxins and are often found along with dioxins.

At lunch the Task Force discussed possible agenda items for the future task force meetings.

The next speaker was Dr. Robert Neal, President, Chemical Industry Institute of Toxicology, Research Triangle Park, Raleigh-Durham, North Carolina. Dr. Neal discussed different situations involving human poisoning with TCDD. He also presented a table showing the results of studies in Sweden, Finland, United States and Germany of humans exposed to TCDD. Dr. Neal stated that studies show that TCDD does produce cancer in mice and rats; however, there is no cause and effect relation between TCDD exposure and cancer yet shown in man but this needs to be investigated further.

The next speaker was Dr. Alvin L. Young, Ph.D., Major, U.S. Air Force, Acting Chief of Research Section, Agent Orange Project Office, Washington, D.C. Dr. Young discussed a series of studies conducted at the Eglin Air Force Base in Florida where a herbicide containing TCDD was sprayed. Studies were done on plants at the site and on deer, rabbits, opossums, beach mice, insects, snakes and birds at the site. TCDD was not found in the deer, opossums or rabbits. However, TCDD was found in beach mice that were around the edges of the water site. TCDD was also found in the insects, in the snakes, in the meadowlark birds and in fish at the bottom of the pond on site. Studies are also being conducted on herbicide levels on Johnston Island and at Gulfport, Mississippi. Dr. Young also discussed other studies being conducted including a study in St. Louis, Missouri on identical twins where one twin is a Vietnam veteran and the other twin served in the military but not in Vietnam.

The final speaker was Dr. Stephen M. Ayres, M.D., Department of Internal Medicine, St. Louis University Medical School, St. Louis, Missouri. Dr. Ayres discussed some of the major and minor criteria for the diagnosis of dioxin associated illnesses. He also recommended that the state pass legislation dealing with hazardous waste, particularly Representative Bob Feigenbaum's bill dealing with funding.

Sharon Rogers and Betty Wilson reported they had both received calls from a Mr. Murray Abrahamson who lives across from the Minker site. He expressed concern for the health and welfare of his family.

The meeting was adjourned at approximately 5:00 p.m.

Respectfully submitted,

Dianne Luebbert

Dianne Luebbert
Secretary

Approved,

James A. Finch Jr.

James Finch
Chairman

4/28/83
Date

DIOXIN TASK FORCE MEETING

April 28, 1983

Department of Natural Resources' Conference Room
Jefferson City, Missouri

MEMBERS PRESENT

James Finch, Chairman
Dwight Douglas
Ray Forrester
Perry King
Carl Marienfeld
Robert Powell
Sharon Rogers
George Roush
James Shaddy
Betty Wilson

ORDER OF BUSINESS

The meeting was called to order at 9:10 a.m.

Dwight Douglas moved to approve the March 30, 1983 and the April 14, 1983 minutes as submitted. Robert Powell seconded the motion. Both sets of minutes were approved as submitted.

The first speaker was Dr. Phillip C. Kearney, Chief, Pesticide Degradation Lab, Agricultural Environmental Quality Institute, Agricultural Research Center, USDA, Beltsville, Maryland. Dr. Kearney first discussed different processes which affect pesticides in the environment, but more specifically the molecule TCDD. The different processes discussed were: sunlight or photochemical degradation, chemical degradation, microbiological degradation or microbial metabolism, leaching, adsorption of a pesticide or TCDD to a soil particle, uptake by plants, and volatility. Dr. Kearney then discussed studies that have been done on a terrestrial ecosystem. This is a way of looking at the life history of a molecule such as TCDD and what happens to it. He then discussed bioaccumulation of TCDD in the aquatic environment, bioaccumulation in farm animals and bioaccumulation from oral and dermal exposure to TCDD in rats. Dr. Kearney referred to a paper by Poiger and Schlatter, Swiss Federal Institute at Zurich, which discussed different types of studies done on rats and compared the different levels of accumulation of TCDD in the livers of these animals. Dr. Kearney then discussed his experiences in Seveso, Italy during the summer of 1976. He was asked to devise a decontamination plan for the Seveso area.

The next speaker was Dr. Jurgen H. Exner, Manager, Engineering/Research and Development, IT Enviroscience, Knoxville, Tennessee. Dr. Exner discussed some of the dioxin treatment techniques and the kinds of problems faced in trying to develop a treatment process. He illustrated some of these problems by giving a brief description of their efforts at Verona. Dr. Exner then discussed the chemistry of dioxin in the soil. He also discussed some of the options that exist for treating dioxin in the soil (e.g. extraction, incineration, etc.).

The next speaker was Dr. Henry Falk, Chief, Special Studies Branch, Chronic Disease Division, Center for Environmental Health, Centers for Disease Control, Atlanta, Georgia. Dr. Falk discussed CDC's roles in the dioxin episode. CDC has been working with EPA in terms of evaluation and interpretation of EPA environmental data as it becomes available and also working with them on the quality assurance aspects of the environmental data. CDC has also worked closely with the Missouri Division of Health in evaluating situations and making public health decisions. Three other points that Dr. Falk also discussed were:

1. The extreme potency of dioxin in a variety of animal species.

2. There is a variability within species and there is a variability between the dose that will cause an acute effect, the dose that will cause a chronic effect, and the dose that one would consider safe.

3. There is a body of knowledge about the effects of dioxin in people that comes mostly from occupational settings.

Dr. Falk also outlined the risk assessment process and the analysis that led to the selection of the 1 ppb level of dioxin in the soil as a level which could be used publically in terms of making decisions about different sites.

Dwight Douglas then gave a slide presentation on some of the dioxin sites in southwest Missouri. He briefly explained the geography of the area including the Neosho site, the community of Verona and the Spring River. The three locations of the contaminated sites are: (1) the digester at the sewage treatment plant, (2) the Water and Wastewater Technical School site, and (3) the Bunker site.

Ray Forrester then provided a 17-minute video tape titled "Toxic Cleanup" that gave a brief synopsis of the Denney Farm Site action which was conducted by Syntex under the supervision of EPA.

Dr. Jim Whitley, Chief of Fisheries Research, Missouri Department of Conservation, briefly discussed studies done in the 1950's and 1960's on aquatic life in the Spring River. The Department of Conservation has also recently collected fish from the Spring River and sampled them for dioxin. Ron Crunkilton, Water Quality Biologist, then discussed the economic importance of the Spring River in southwest Missouri. He stated the river contains one of the most diverse fish populations in the state. He also stated that the Food and Drug Administration advisory levels on dioxin have been set. Mr. Crunkilton discussed averages and ranges of dioxin found in different kinds of

DIOXIN TASK FORCE MEETING

May 12, 1983

Ramada Inn, Roanoke Room
Jefferson City, Missouri

MEMBERS PRESENT

James Finch, Chairman
Dwight Douglas
Ray Forrester
Perry King
Carl Marienfeld
Robert Powell
Sharon Rogers
George Roush
James Shaddy
Betty Wilson

ORDER OF BUSINESS

The meeting on Thursday, May 12, 1983, was called to order at 9:20 a.m.

The minutes from the April 28, 1983 task force meeting were approved as submitted.

Beth Rice, Waste Management Program, Department of Natural Resources, stated that the first company on the agenda, Midland Ross Corporation, did not wish to make a presentation. She passed out a statement from Irving Williams that stated the reasons why they did not wish to make a presentation.

The next presentation was by George VanderVelde, Technical Director for Chemical Waste Management, and Darrell Schimeck, a project administrator for Superfund activities, also of Chemical Waste Management. Mr. Schimeck stated there were nine key elements or factors they evaluated in determining a successful project. They are:

1. Public health and safety during operations and in resulting solution
2. Technically feasible
3. Operationally sound
4. Provides a solution that is environmentally sound and defensible
5. Compliance with regulations
6. Timing
7. Cost
8. Public reaction/opinion/perception in Missouri
9. Public reaction/opinion/perception in other states.

Chemical Waste Management then evaluated four potential treatment or disposal options in terms of these nine factors, breaking each down in positives and negatives and then made a recommendation for each option. The first option, incineration of dioxin contaminated soil, was recommended as a good option. The second option, secure burial, was recommended as a poor option. The third option, treatment of the dioxin contaminated soil by either physically or chemically neutralizing the dioxin contaminants, was recommended as a good option. The fourth option, site capping/encapsulation, was recommended as a good option.

Chemical Waste Management made the following conclusions:

1. Due to the volume of soil, destruction of dioxin with the soil is cost prohibitive.
2. Since dioxin is a major concern, dioxin should be extracted from the soil in order to again reduce the volume.
3. The dioxin which is excavated or extracted should be destroyed chemically and/or incinerated.
4. Again due to the volume of low level dioxin contaminated soil, removal and destruction of the dioxin with the soil is cost prohibitive.
5. Site capping and encapsulation should be considered as an alternative solution for select low level contaminated sites.
6. Because of public reaction and sensitivity by other states to receiving dioxin, as much of the dioxin processing and disposal should be done within the State of Missouri as is possible.

Considering those conclusions Chemical Waste Management's recommendations for primary operation are as follows:

1. Excavation and recapping of high level dioxin sites.
2. Concurrent capping and encapsulation of the low level dioxin sites.
3. Extraction of the dioxin from the excavated soils.
4. Disposal via a secure burial of soil following the dioxin extraction.
5. Treatment/destruction of dioxin contaminated soil extract medium via the ultraviolet light process.
6. Ocean incineration of the treated soil extract medium.

Based upon the current level of information, Chemical Waste Management estimated the total cost to be between $22-$65 million and the total time of the project completion to be 14-24 months.

George VanderVelde then discussed a proposal to build a facility within the state that would involve chemical separation. The process would remove the dioxin from the soil, concentrate that dioxin into a liquid medium which could then be reduced in terms of dioxin that is present through the means of a UV process. The UV process would reduce the level of dioxin. The liquid material which contains the bulk of the dioxin would be incinerated and the very low level material left in the soil would then be buried in a secure landfill.

The next presentation was by Tom Cody, Vice-President of Critical Fluids Systems, Inc. Mr. Cody discussed Critical Fluids Systems' technology which is based on the use of condensed gases as extracting solvents. The technology has never been applied specifically to dioxin, but has been successful in extracting other chemicals and materials from the soil. Critical Fluids Systems proposes that a small-scale test program be done to determine the feasibility of utilizing critical fluid extraction technology. After the test program, a recommendation would be made on the feasibility of proceeding with subsequent phases leading to construction of a full-scale processing plant to be operated by a waste management company. The cost of the proposal would be as follows:

Set-Up (6 months)	$ 350,000
Run	500,000
Pre-Design Engineering Package (3 months)	50,000
Extraction Plant (process 3.5-7.0 tons/hour)	3,000,000

The next presentation was by Tony Schraub, Mechanical Engineer, and Leo Weitzman, Chief Scientist, from Acurex Waste Technologies, Inc. Mr. Schraub discussed their process which destroys dioxin by chemical transformation of the dioxin molecule and produces a safe polymer. The Acurex dioxin soil cleanup process would involve the following steps:

1. Move portable equipment to contaminated site
2. Preparing the soil (wetting it thoroughly so that dust is eliminated or reduced)
3. Scoop dioxin soil directly into soil washing machines
4. Wash soil with agitation in special Acurex solvent
5. Remove solvent from soil by vacuum extraction
6. Return safe soil to original location
7. Purify solvent and concentrate pollutant into small-volume sludge
8. Treat sludge with Acurex dioxin and PCB destruction process rendering harmless
9. Remove equipment and sludge, leaving clean site
10. Regreen site as appropriate.

Some of the benefits of the Acurex soil cleanup solution are: cleans dioxin or PCB from soil to specified level; destroys the dioxins; safe (nonflammable, etc.); process already demonstrated in Missouri; no transport of contaminated soil from site; controllable and verifiable; creates no secondary pollutants or migration; and returns the site to an environmentally safe and clean condition. The preliminary cost, assuming 10,000 cubic yard cleanup at a site which is relatively accessible, would be $200-$500 per cubic yard.

The next presentation was by John Schofield and Jurgen Exner of IT Enviroscience. Mr. Schofield discussed two solutions for destroying dioxin: (1) destruction by thermal oxidation or incineration and (2) destruction by a chemical means. Dioxin could be destroyed by a chemical process such as the ultraviolet process. This would be a potential solution for a site that is

lightly contaminated with dioxin that is fairly close to the surface. The cost for such an in situ chemical process would be approximately $50 per ton. The other solution would be destruction of the material by incineration in a cement kiln. Cement kilns could handle thousands of tons per day. Two things would be required: (1) to prove to the public that incineration can destroy dioxin (this demonstration could be done by using the EPA mobile incinerator) and (2) carry out engineering feasibility of converting a cement kiln to a soil incinerator. This process would cost approximately $200 per ton.

The next presentation was by James L. Boyland, Director of Business Development for the Midwest Region for SCA Services. Mr. Boyland stated that SCA Services believes incineration is the best proven technology for destruction of dioxin and that a cement kiln would offer the best solution. They have not estimated any costs as of yet. Mr. Boyland also discussed a team that SCA Services had formed to look into the problem. Battelle Columbus Laboratories is on this team to assess, to evalute and to recommend technologies. Fru-Con Corporation is also on this team as specialists in the design and construction of any kinds of facilities that would be anticipated. SCA Services would be the prime contractor and operator for the project.

The next presentation was by Ed Hillier, Field Services Group of Rollins Environmental Services, Inc. and Don Matter, Field Services Manager. Mr. Hillier proposed that off-site incineration may be feasible for small amounts of dioxin, assuming you would want to move the material as fast as possible. Rollins Environmental recommends above ground storage of the material until new technlogies are developed and proved to be effective. The estimated cost for off site incineration for 500,000 cubic yards would be $234,000,000 which includes removal and transportation. The time period would be approximately 5600 days. The estimated cost for above ground storage for 500,000 cubic yards would be $26,600,000 which includes excavating, transportation, construction and waste placement. Don Matter discussed the option of incineration. He stated that the ash from incineration would still have to be made secure in a licensed permitted facility.

Ron Kucera, Department of Natural Resources, informed the task force of the results of his trip to Washington, D.C. and his testimony before the Science and Technology Committee that was requested by Congressman Volkmer. He indicated to the committee that Missouri would benefit by an extension of the Superfund Act and that Missouri would like to have some additional R & D monies for research needs.

Greg Peterson, CH2M Hill, the firm contracted to do the Minker/Stout feasibility study, provided additional information on temporary stabilization of the material at the Minker/Stout site until new technology is developed. The firm looked at approximately 20 alternatives, including a polyurethane spray foam. The cost for this, including monitoring wells, would be between $1-$2.5 million.

The task force then brought up the question to Dick Smith, U.S. Environmental Protection Agency, that if a site on the National Priority List did some type of interim action such as temporary cover, if that would cause the site to be removed from the list since there would no longer be an immediate risk?

Dave Bedan, Waste Management Program, Department of Natural Resources, then went over the different chapters in the draft of the interim report. The task force then discussed whether Chapter 5, The Theory of and Procedures for Health Risks Assessment, should be included in the interim report. It was decided that the title of Chapter 5 should be changed and should include what the Division of Health has been doing and what their interaction with CDC has been. It was also decided that Chapter 6 would be discussed in further detail at Friday's meeting and if time permitted, there would be discussion on proposed revisions to EPA's new regulation, otherwise this item would be put on the May 26 agenda. A suggestion was also made that there should be a statement in Chapter 6 making it perfectly clear that the recommendations were site specific and are not recommendations for other sites which have not yet been adequately addressed.

The meeting was adjourned at approximately 5:00 p.m.

Respectfully submitted,

Dianne Luebbert

Dianne Luebbert
Secretary

Approved,

James G. Finch

James Finch
Chairman

5/26/83
Date

DIOXIN TASK FORCE MEETING

May 13, 1983

Ramada Inn, Roanoke Room
Jefferson City, Missouri

MEMBERS PRESENT

James Finch, Chairman
Dwight Douglas
Ray Forrester
Perry King
Carl Marienfeld
Robert Powell
Sharon Rogers
George Roush
James Shaddy
Betty Wilson

ORDER OF BUSINESS

The meeting on Friday, May 13, 1983, was called to order at 8:10 a.m.

The task force discussed several recommendations and suggestions for the interim report due on June 1, 1983. These suggestions and recommendations were as follows:

1. The report should address only the Minker/Stout and Times Beach sites. The remaining dioxin sites should be listed in the appendix with a statement that they are being included for information only.

2. On page 3 of the "Historical Summary" (3rd paragraph), there should be a note to refer to the body of the report for further clarification of half-life.

3. Would like to see additional sampling at various points in Times Beach to determine levels of contamination and to determine the extent of the problem.

4. Would like to see surface water and ground water sampling by use of bio-indicators and activated carbons and resins to determine if contamination exists and then to determine if that contamination is a result of leaching or sediment transport.

5. The report should outline the effects of the buyout at Times Beach. It should state that actions already taken have alleviated the problem and have removed the immediate risk.

6. The report needs to state that interim stabilization of the soil at the Minker/Stout site needs to be done. For instance attach a pipe to the drain pipe that runs under the road and run that pipe down off the hill. The report then should state that remedial work needs to be done at both the Minker/Stout and Times Beach sites.

7. Should assign priorities in the report. Minker/Stout should be given first priority and state the reasons why it should be first. Minker/Stout is an unstable site, whereas Times Beach is more stable.

8. Specific conclusions and recommendations for Times Beach:

   a. Buyout should be expedited. Should include removal of people. Access should be limited.

   b. With reduced exposure there is no need for further immediate action. Testing will continue.

   c. Health risks:

      (1) Has been reduced because of removal of exposure.

      (2) Study of health effects to residents should be broadened and continued.

      (3) Will reassess health effects.

   d. Initial remedial action - Taking measures to limit access. When state obtains title, then can totally restrict access.

   e. Planning for final remedial action should be continued based upon further study.

9. Specific conclusions and recommendations for Minker/Stout:

   a. Buyout should be expedited.

   b. Immediate remedial action is called for. Short term action is in order such as culvert, sod, and grass to stop erosion.

   c. Planning for final remedial action should be continued. Should have statement about geology at the site. Should proceed with all deliberate speed.

10. Should select three or four of the options for remedial action the task force heard about and place emphasis on them.

11. State or federal government should consider a centralized location for a treatment facility or storage area.

12. Small sites should not use portable equipment but should take material to state or federally owned area.

13. Monitoring should be done at Minker/Stout site after drain pipe installed and other initial action completed.

14. Soil from one of the sites should be sent to the Pine Bluff, Arkansas incinerator for a test burn.

The task force then discussed the different options for remedial action. A summary of the discussion for each option is given below:

Stabilization In Place - A grout curtain is not a recommended action for the Minker/Stout or Times Beach sites, but may be used for other sites. Discuss further under further studies. Also recommended long-time research into organic polymers as fixatives.

On-Site Storage - Do not recommend on-site storage at each and every site. Portable equipment would be burdensome to move, would cost a large amount of money, would require individual permits, and would have to set up such things as generators, water, power, etc. Recommend one centrally located facility and bring all the material to that facility to store, treat, etc. Recommend a preliminary study that would look into possible sites where a facility and storage space could be constructed. In most cases on site storage would appear not to be feasible, but there may be some special situations where it could be used.

Transport to Secure Landfill - Do not recommend as an option to pursue unless all other high technology fails.

Biodegradation - Recommend further research.

Incineration - Recommend a pilot burn at Pine Bluff to see if ash residue will be acceptable for non-hazardous disposal. Will have to determine if the dioxin is destroyed or if it is sent into the atmosphere. Request priority treatment to be placed on test list. Request research permit so this test can be done. Suggested someone might be able to visit Pine Bluff.

Extraction - Recommended further study in the field of extraction. Make a distinction that this is not an end solution.

In-Place Treatment - Recommended further research. This is not an immediate available solution. Photolysis process is not an end solution to problem. Recommended further research on ultraviolet radiation, gamma radiation, and lasers.

Temporary Storage or Stabilization Until New Technology Develops - Do not recommend as an option.

A summary list of those recommendations for further research are: organic polymers, incineration to a certain extent, extraction, biodegradation, in-place treatment such as ultraviolet radiation, gamma radiation, lasers, etc. and bioavailability.

Dick Smith, U.S. Environmental Protection Agency, also discussed a study that will begin in the near future by the Division of Geology and Land Survey on Romaine Creek. They will be looking at the sediment transport issue and will be determining general ground water movements in the Minker/Stout area. DGLS will be installing stream gauges and will be injecting dye at various points in the stream basins. They will also be surveying wells in the area.

Dick Smith also addressed a question from the previous day about whether a site that is on the National Priority List and has completed interim action that has reduced a risk, whether that site would be taken off the list because of the interim action. Mr. Smith stated that once a site has received a hazard ranking score sufficient to put it on the National Priority List, that site is not re-scored at any point. It remains on the list until final action is completed.

It was also decided that the next meeting would remain on May 26 instead of May 23. There had been discussion at the previous meeting to change the date to May 23.

James Shaddy suggested that since the task force had mentioned several topics that need further study or further research, that they could possibly solicit research needs from the University of Missouri - Columbia coordinator.

The meeting was adjourned at 2:40 p.m.

Respectfully submitted,

Dianne Luebbert

Dianne Luebbert
Secretary

Approved,

James A. Finch

James Finch
Chairman

5/26/83

Date

APPENDIX III

LIST OF REFERENCES

The following is a partial list of the multitude of documents available on the topic of dioxin.

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APPENDIX IV

PROCEDURES FOR SELECTING A REMEDIAL ACTION

Background

Section 104(a)(1) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authorizes the President to provide remedial actions which are necessary to protect the public health, welfare, or the environment at waste sites. The National Contingency Plan (NCP) provides the regulations necessary to implement CERCLA and outlines the basic procedures for selecting a final remedial action. Pursuant to a delegation of authority, the EPA Assistant Administrator for Solid Waste and Emergency Response is empowered to approve the selection of remedies for hazardous waste sites. The statutory and regulatory requirements for documenting the remedy selection are discussed in the following sections.

CERCLA Requirements

The selection of the final remedial action occurs after the completion of the feasibility study and is subject to fundamental statutory requirements contained in CERCLA. The key declarations that are necessary for every remedial action recommendation are:

1. EPA has consulted with the State before determining the appropriate remedial action [Section 104(c)(2)];

2. The action being taken is (a) a cost-effective solution and (b) appropriate when balanced against the need to use Trust Fund money at other sites [Section 104(c)(4)];

3. The proposed remedy effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare and the environment; and

4. When the selected action involves off-site disposal, these additional declarations are, also, satisfied [Section 101(24)]:

   a. The action is the most cost-effective when compared to other possible remedial actions;
   b. The action will create new capacity to manage, in compliance with the Solid Waste Disposal Act, hazardous substances in addition to those located at the site in question; and
   c. The action is necessary to protect the public health, welfare, or the environment from a present or potential risk which may be created by further exposure to the continued presence of such substances.

NCP Requirements

The NCP regulations outline certain procedures for identifying, evaluating and selecting a remedial action which provides a permanent remedy to prevent or mitigate the migration of a release of hazardous substances into the environment. These regulatory procedures are based upon the statutory requirements contained in CERCLA and are summarized below.

1. Development of Alternatives - A limited number of alternatives is developed for either (1) source control actions where wastes remain at or near the area where they were originally located; (2) off-site remedial actions when wastes have migrated off-site; or (3) both types of actions.

2. Initial Screening of Alternatives - The alternatives developed are subject to an initial screening to narrow the list of potential remedial actions for further detailed analysis. The alternatives are evaluated according to these factors: (1) costs; (2) environmental effects and overall effectiveness; and (3) acceptable engineering practices.

3. Detailed Analysis of Alternatives - A more detailed evaluation is conducted of the limited number of alternatives that remain after the initial screening.

4. Selection of Remedial Alternative - The lead agency (either EPA or the State) selects the remedial alternative which the agency determines is cost effective (i.e., the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare or the environment).

Development of the Record of Decision (ROD)

The mechanism that has been developed to document the remedial action selected is the ROD. This decision document is prepared by EPA with assistance from the State whether EPA is the lead agency or not. The ROD, also, insures that the selected remedy is based upon appropriate data and is in accordance with the CERCLA requirements and Superfund policy.

The following activities provide an outline of the review and approval process necessary to select and implement a remedial action. Deviations from this outline of activities may occur depending on the nature and complexity of the site. Also, the length of time necessary to accomplish these tasks will depend on these same factors.

1. The draft feasibility study is submitted for review.

2. The EPA Regional Office reviews the draft feasibility study for compliance with the NCP.

3. The Regional Office confers with the State on the results of the feasibility study to ensure that the State concerns are adequately addressed in recommending appropriate remedial actions.

4. The Regional Office prepares a draft ROD to obtain approval to initiate remedial actions.

5. The State assists the Regional Office in developing information to support the ROD recommendation and submits a letter indicating the State's support of the selected remedial action.

6. The Regional Office provides a three (3) week public comment period regarding the draft feasibility study and draft ROD followed by a public meeting to receive citizen comments.

7. The public comments are incorporated into the draft feasibility study and draft ROD and the Regional Office prepares a responsiveness summary outlining the public comments and providing EPA's responses to them.

8. The draft ROD and supporting documentation are submitted to EPA Headquarters for review.

9. The Regional Office in cooperation with the State then develops the final ROD after incorporation of the Headquarters' comments.

10. The Regional Office submits the final ROD to Headquarters for approval.

11. The Assistant Administrator for Solid Waste and Emergency Response approves the ROD after balancing the need for the remedial action at this site against the amount of money available in the Fund to respond to other sites.

12. Following approval of the ROD, funds for the remedial action will be obligated and the activity will be implemented through a Cooperative Agreement or a new or amended State Superfund Contract which provides all required State assurances, including assurance of the availability of an acceptable hazardous waste disposal facility.

April 1983
Superfund Section
U.S. Environmental Protection Agency

APPENDIX V

TESTIMONY OF
MISSOURI DEPARTMENT OF NATURAL RESOURCES
BEFORE COMMITTEE ON SCIENCE AND TECHNOLOGY
(U.S. CONGRESS)

May 4, 1983

Mr. Chairman, Members of the Committee.

My name is Ron Kucera. I would like to extend my thanks to the committee for the opportunity to appear here today to discuss the subject of alternatives to the landfilling of hazardous waste. I serve as deputy director for the Missouri Department of Natural Resources. Our Department has responsibility for parks management, historic preservation, geologic resources, energy, and environmental quality. Without a doubt the most difficult issue facing our agency has been the management of hazardous waste including wastes currently generated as well as those which did not receive proper or adequate disposal in the past.

I am proud to say that it is the policy of the State of Missouri, enunciated in statute, to discourage the landfilling of hazardous waste. In 1980 the Missouri General Assembly passed amendments to the State's hazardous waste law enacting more stringent standards for the permitting of landfills, placing a tax on the generation of hazardous waste, and requiring the use of practical alternatives to landfilling. The injection or landfilling of bulk liquid hazardous waste is entirely prohibited. Missouri is a leader among the states in reducing the dependence on landfilling for the management of hazardous waste. Currently, less than 5% of wastes generated in Missouri are destined for disposal by landfilling. We are now vigorously pursuing further amendments to our waste law which will place a very substantial tonnage tax on all hazardous waste that is disposed of through landfilling. We are confident that this new law will provide strong additional incentives to Missouri industries to invest in process changes, recycling, treatment, and incineration. The revenues from this new tax will be targeted to the correction of problems caused by poor waste management practices of the past.

As the members of this committee are most certainly aware, the public policy concerns over the use of landfills are not restricted to the matter of current and future waste generation. The clean-up of old inadequate or leaking waste sites often yields large volumes of waste that must be managed by legally approved hazardous waste facilities. If, as is frequently the case, large quantities of contaminated soil are involved, landfilling usually is thought to be the least-cost option when compared to treatment or incineration. Though we do not yet have good cost estimates, this relationship appears to hold for the remedial action alternatives available for many of Missouri's dioxin sites.

I would like to take just a minute to acquaint the committee with the numbing reality of the dioxin problem that we are facing in Missouri. It is a dilemma of almost unfathomable proportions, and there is no tonic cure, no easy

solution. As of this week our Department's investigators working cooperatively with the staff of the Kansas City regional EPA office had confirmed through quality-assured sampling and analysis the existence of 30 separate dioxin sites in Missouri. Our investigators continue to find additional leads, and if the current trends persist, we will no doubt confirm more contaminated sites.

It is estimated that the total volume of contaminated soil with greater than one part per billion 2,3,7,8 tetrachlorodibenzo-p-dioxin could exceed 400,000 cubic yards or 500,000 tons. The oft-suggested solution of high temperature incineration could easily cost more than $2,000 per ton or more than $1 billion for all the dioxin contaminated material known to date in Missouri. Another alternative, solvent extraction with subsequent incineration or ultraviolet photolytic degradation would most likely involve even higher costs. Furthermore, investigations may reveal similar though perhaps smaller dioxin problems in Arkansas, California, Illinois, Kansas, Michigan, New Jersey, New York, Ohio, Oregon, and Pennsylvania. Obviously, the large potential costs for incineration and solvent extraction technologies could exceed the capability of the federal Superfund.

If we must decide between the less costly options of landfilling and some hybrid of on-site stabilization and land treatment, then it is abundantly clear that we must know more about the fate of dioxin in soil as a function of time. Unfortunately, we have found that there are crucial information deficiencies. The basic research that would allow us to make confident predictions about the behavior and half-life of dioxin in Missouri soils has not yet been initiated. Fundamental questions about the naturally occurring reduction of dioxin concentrations in soil through photolysis, biotic activity, volatilization, and solution have not been answered with adequate precision. Amazingly, after all the years of debate, we do not yet have a good handle on the half-life of dioxin in soil, nor do we know which degradation process predominates. Hopefully, through research we may learn that there are effective methods for enhancing and accelerating natural dioxin degradation in on-site applications. It should be noted that natural degradation processes might be severely reduced in the environment of a landfill thereby guaranteeing lengthy persistence of the dioxin.

It is vital to our efforts in Missouri that the research and development program within EPA provide accelerated funding to dioxin-related research activities. This is definitely not the appropriate time to diminish the EPA budgetary commitment to research. We cannot afford to base multimillion dollar remedial action decisions on nickel research.

APPENDIX VI

CONFIRMED DIOXIN SITES

Barry County

Denney Farm

Callaway County

Timberline Stables

Franklin County

Quail Run Mobile Home Park

Greene County

Syntex Facility - Springfield

Jefferson County

Bubbling Springs Ranch
Cashel Residence
Minker Residence
Romaine Creek
Ruth Sullins Property
Stout Residence
Saddle and Spur Club
Sandcut Road

Lawrence County

Bill Ray Farm
Erwin Farm
Rusha Farm
Syntex Facility
Spring River

Lincoln County

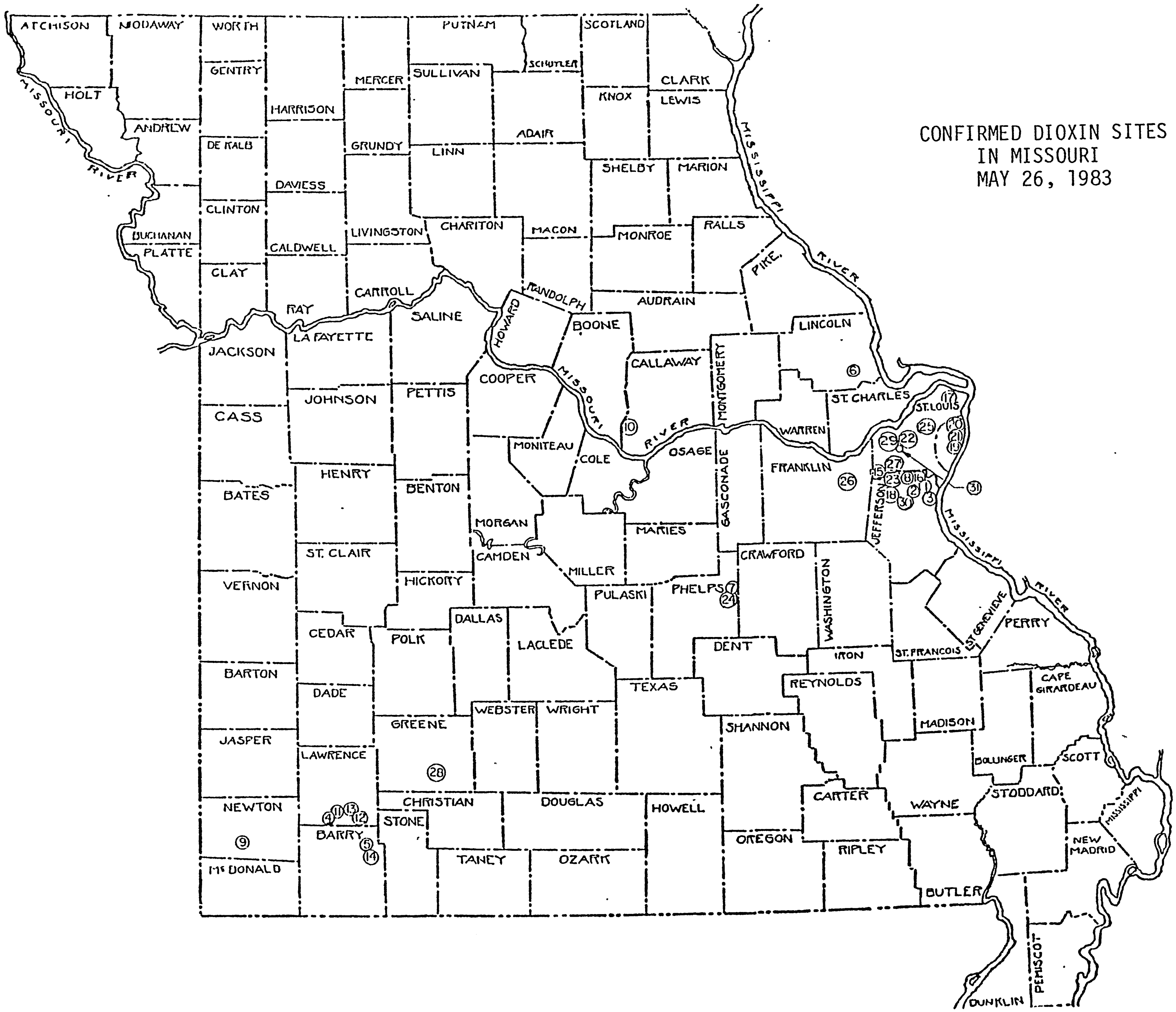
Shenandoah Stables

Newton County

Neosho Digester, Trench Tank, Spill Area, and Wastewater School

Phelps County

Bliss Farm Road
Walls Property and Piazza Road



CONFIRMED DIOXIN SITES
IN MISSOURI
MAY 26, 1983

May 26, 1983

SUMMARY OF SITES WHERE THE PRESENCE OF DIOXIN HAS BEEN CONFIRMED

1. Minker Residence Site:

   This site is located near Imperial. The known concentrations of dioxin at the site range from .3 to 300 ppb. The contaminated soil at this site originated at the Bubbling Springs Stables. MDNR geologists indicate that this site is in a very poor geological setting. EPA personnel have conducted intense sampling at the site. Contaminated soil from this site has eroded to three (3) adjacent properties. This site along with Romaine Creek and the Stout Residence Site is included on the National Priorities List. A State Superfund contract has been signed with the State for these three sites. The contract covers relocation and a Feasibility Study for the sites.

2. Romaine Creek:

   Drainage to Romaine Creek comes from Minker and Bubbling Springs areas. The known concentrations of dioxin in thee creek sediment range from .3 to 272 ppb. EPA is conducting future sampling and investigation. This site along with Minker and the Stout Residence Site is included on the National Priorities List. A State Superfund contract has been signed with the State for these three sites. The contract covers relocation and a Feasibility Study for the sites.

3. Stout Residence Site:

   This site is located near Imperial. The known concentrations of dioxin at this site range from 2.1 to 21 ppb. The contaminated soil at this site originated at the Bubbling Springs Stables. EPA is presently investigating this site and conducting additional sampling. This site along with Romaine Creek and the Minker Residence Site is included on the National Priorities List. A State Superfund contract has been signed with the State for these three sites. The contract covers relocation and a Feasibility Study for the sites.

4. Spring River:

   This river flows along the property line of the Syntex plants and runs westward. EPA, Missouri Department of Conservation (DOC) Division of Health, and MDNR have combined efforts to investigate the dioxin problem in the river. Sediment samples analysis indicate dioxin levels in the river sediment range from .004 to .087 ppb. Sampling of the fish in the river indicates dioxin levels in the fish flesh range from .019 to .04 ppb. The DOC has issued a warning to the people of the area to limit their fish consumption. A continued sampling effort is being conducted to determine if seasonal trends develope.

5. Denney Farm Site:

This site is located near Verona. This site originally contained levels ranging from 50,000 to 2,000,000 ppb. These high levels are from drum samples buried at the site. EPA and Syntex are working to complete the clean-up of the site. This site has been fenced and buried wastes have been dug up and secured above ground. Syntex has accepted responsibility for this site. The remedial work has been conducted by Syntex under the terms of a Consent Decree.

6. Shenandoah Stables Site:

This site is located near Moscow Mills. The known levels of dioxin at this site range from 1.4 to 1750 ppb. This is another site that was investigated by both EPA and CDC in 1974. The higher concentrations at the site are in the slough area adjacent to the arena. Some of the contaminated material was used as fill material along Highway 61 near the stables. Recent investigations have been unable to confirm dioxin in the fill material. The site is included on the National Priorities List. An Administrative Order to close the arena has been sent to the owner for signature.

7. Bliss Farm Road Site:

This site is located near St. James. The known levels of dioxin at this site range from .1 to 382 ppb. These concentrations are much lower than the concentrations of the samples taken by CDC in 1974.

8. Bubbling Springs Ranch Site:

This site is located near Fenton. The known concentrations of dioxin at this site range from 1.4 to 95 ppb. The site was originally investigated by both EPA and CDC in 1974. Contaminated soils have been excavated over the years and used as fill material at the Minker Stout, Sullins, and Cashel properties. An Administrative Order to close the arena has been sent to the owner for signature.

9. Neosho Digester, Trench, Tank, Spill Area, and Wastewater School:

This site is located near Neosho. The known levels of dioxin at the tank and spill area range from 62 to 1900 ppb. The known levels of dioxin at the digester and trench range from .49 to 60 ppb. EPA, the City of Neosho, and the Receiver of the defunct Wastewater School are negotiating the permanent capping and clean-up of the site. This capping will protect the public from contact until EPA determines an allowable amount of dioxin in the soil. Hopefully, action at this site will be completed by January 1, 1983.

10. Timberline Stables:

This site is located near New Bloomfield. The known levels of dioxin at this site range from .7 to 53 ppb. This is another site that was investigated by both EPA and CDC in 1974. Some of the contaminated soil was supposed to have been disposed of at the Jefferson City Landfill on Highway 94. Investigations thus far have not located any dioxin at the landfill. An Administrative Order to close the arena has been sent to the owner for signature.

11. Erwin Farm Site:

This site is located near Verona. The known levels of dioxin at the site range from .006 to .83 ppb. The higher concentration is from a composite sample of drums being stored at the site. EPA has been working with Mr. Erwin & Syntex to accomplish the clean-up of the site.

12. Rusha Farm Site:

This site is located near Aurora. The known levels of dioxin at the site range from .4 to 8 ppb. The higher concentration is from a sample of one drum of filter cake material being stored at the site.

13. Syntex Facility - Verona:

This site is located near Verona. It consists of several disposal areas on the Syntex Plant property. EPA has been working with Syntex to clean up the site. Syntex has accepted responsibility for this site and is conducting a field investigation under the terms of an Administrative Order to determine the extent of contamination. The level of dioxin in wastes stored on site is about 500 ppb.

14. Bill Ray Farm Site:

This site is located near Verona. It consisted of eighteen (18) drums removed from the NEPACCO (Syntex) property. Investigations indicate fifteen (15) drums are empty, one (1) drum contained no detectable amounts of dioxin, and two (2) drums with detectable amounts of dioxin. EPA has negotiated with Syntex to return the two (2) drums to the Syntex property.

15. Times Beach Site:

This site consists of the twenty-eight (28) miles of roads in Times Beach and the city park area. The known levels of dioxin range up to 300 ppb. EPA and MDNR are investigating solutions to the problem. CDC has recommended evacuation of the town. The City is included on the National Priorities List.

16. Ruth Sullins Property:

This site is located near Imperial. The known concentrations of dioxin at the site range up to 100 ppb. The contaminated soil at this site originated at the Bubbling Springs Stables and covers the corner of her three quarter acre lot. EPA expects to combine this site with the Minker/Stout/Romaine Creek site.

17. Southern Cross Lumber Company Site:

This site is located in Hazelwood. The known concentrations of dioxin at the site range up to 27.3 ppb. The site was sprayed by Bliss from 1970-76. The site is now covered with gravel.

18. Saddle and Spur Club Site:

This site is located in northern Jefferson County. The known concentrations of dioxin range up to 15 ppb. Investigations indicate the area was oiled by Bliss late '71 or early '72. The stable property is approximately five (5) acres. The arena floor has been covered with sand. An Administrative Order to close the arena has been sent to the owner for signature.

19. Hamill Transfer Company Site:

This site is located in south St. Louis. The known concentrations of dioxin at the site range up to 15.6 ppb. The site was oiled by Bliss on May 27, 1972, using 8,000 gallons of waste oil. Since that time, the site has been "sealed" with a five (5) inch tar and gravel mixture.

20. Overnite Transfer Inc., Site:

This site is located in north St. Louis. The known concentrations of dioxin at the site range up to 9.2 ppb. The site was oiled by Bliss annually between 1962 and 1976. The site is now a five (5) acre graveled parking lot.

21. Jones Truck Lines Site:

This site is located in north St. Louis, The known concentrations of dioxin at the site range up to 22 ppb. The site was oiled by Bliss in the early '70's. Since that time, the site has been paved with asphalt and is now being used as a 4-5 acre parking lot.

22. Methodist Church Site:

This site is located near Ellisville. The known concentrations of dioxin range up to 3.5 ppb. The site was oiled by Bliss in the early 70's. Since that time the site has been paved with asphalt and is now being used as parking for the church.

23. Cashel Residence Site:

This site is located across Romaine Creek Road from Bubbling Springs Stables. The known concentrations of dioxin range between 10 and 100 ppb. The contaminated soil at this site originated at the Bubbling Springs Stables. EPA expects to combine this site with the Minker/Stout/Romaine Creek site.

24. Wall Property and Piazza Road Site:

This site is located near St. James. The known concentrations of dioxin range between 5 and 100 ppb. This site is adjacent to the Bliss Farm Road Site. Piazza Road was oiled by Bliss at the same time Bliss oiled his own road.

25. Russell Bliss Oil Company (Frontenac) Site:

This site is located in Frontenac. The known concentrations of dioxin range up to 100 ppb. This site was used by Bliss to store and mix waste oil until 1977.

26. Quail Run Mobile Home Park:

This site is located near Gray Summit. The known concentrations of dioxin range up to 1100 ppb. EPA's investigation indicates that Bliss oiled the roads at the Mobile Home Park.

27. Sontag Road Site:

This site is located in Castlewood. The known concentrations of dioxin at the site range from 1 to 60 ppb. This site was oiled by Bliss to control dust. This road has since been paved.

28. Syntex Facility - Springfield:

This site is located in Springfield. The known concentrations of dioxin range up to 8 ppb. This site consists of a holding lagoon which is being closed by Syntex under RCRA. EPA is working with Syntex to accomplish the clean up of the site.

29. Mid-America Arena Site:

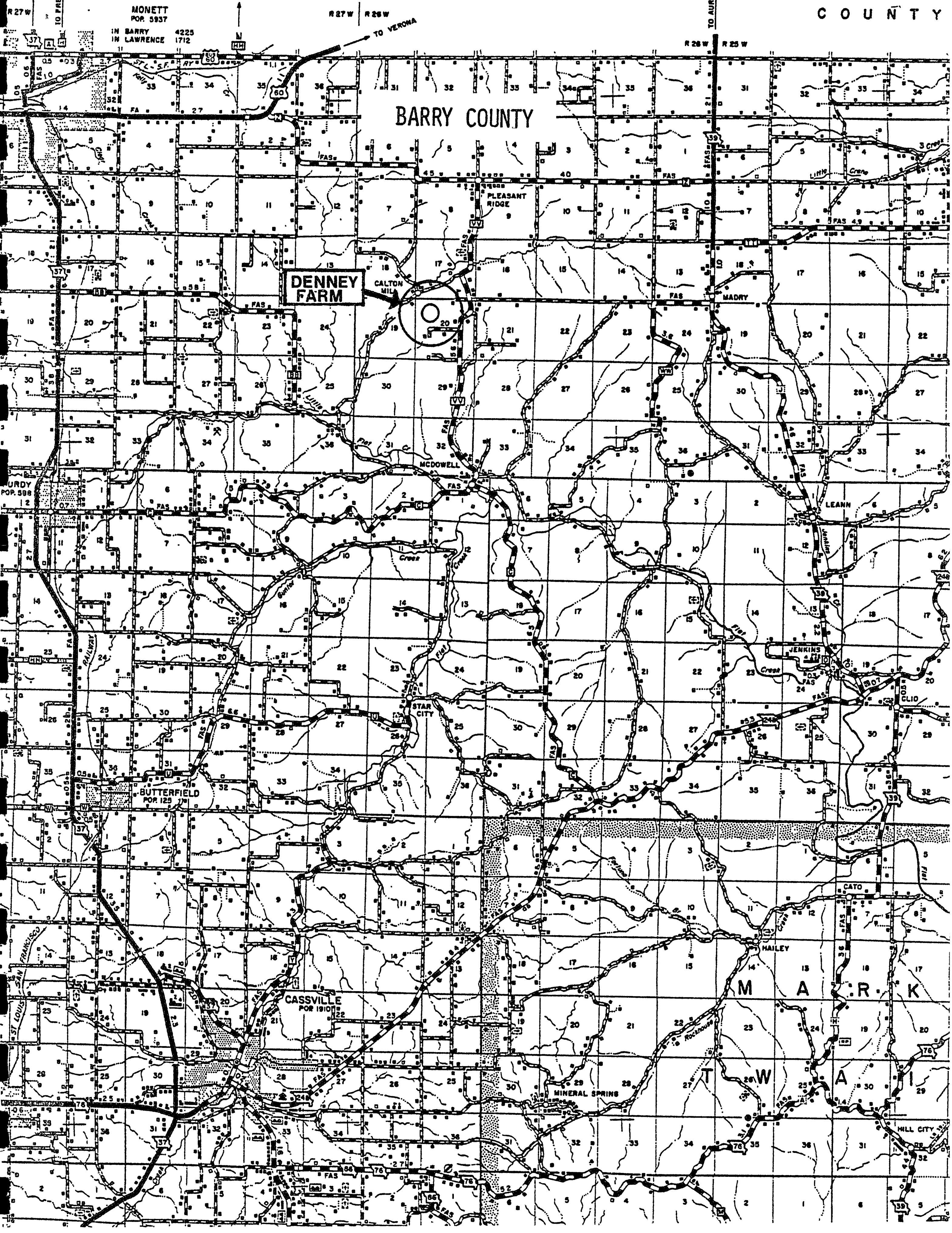
This site is located near Ellisville. The known concentrations of dioxin range up to 78 ppb. This arena is part of the "Ellisville Area Site" which appears on the National Priority List. A Superfund Cooperative Agreement has been signed for the clean up of this site.

30. Sandcut Road Site:

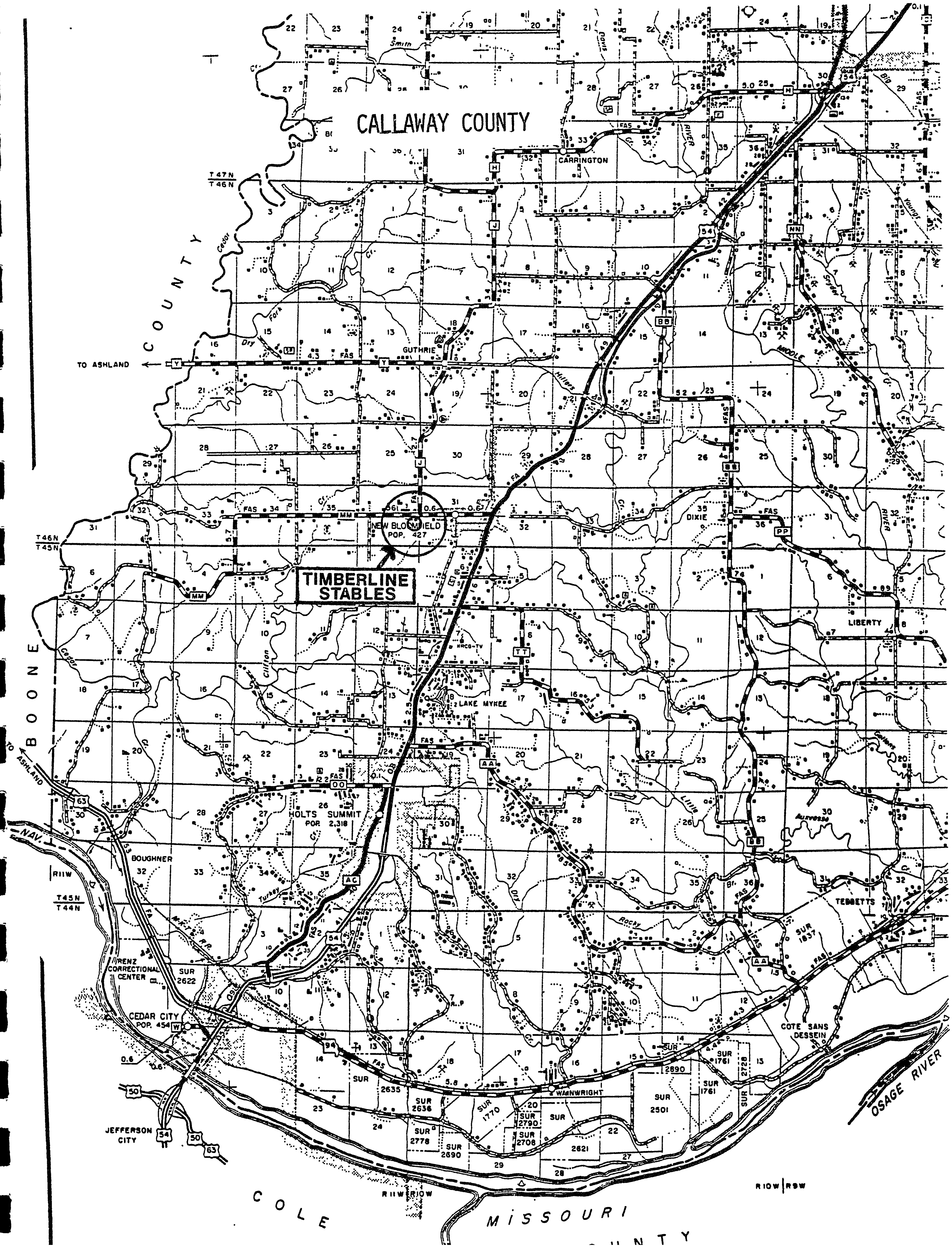
This site is located near Cedar Hill. The known concentrations of dioxin range up to 24 ppb. A former driver for Bliss Oil lived in a trailer along this road and routinely "oiled" the road to control dust.

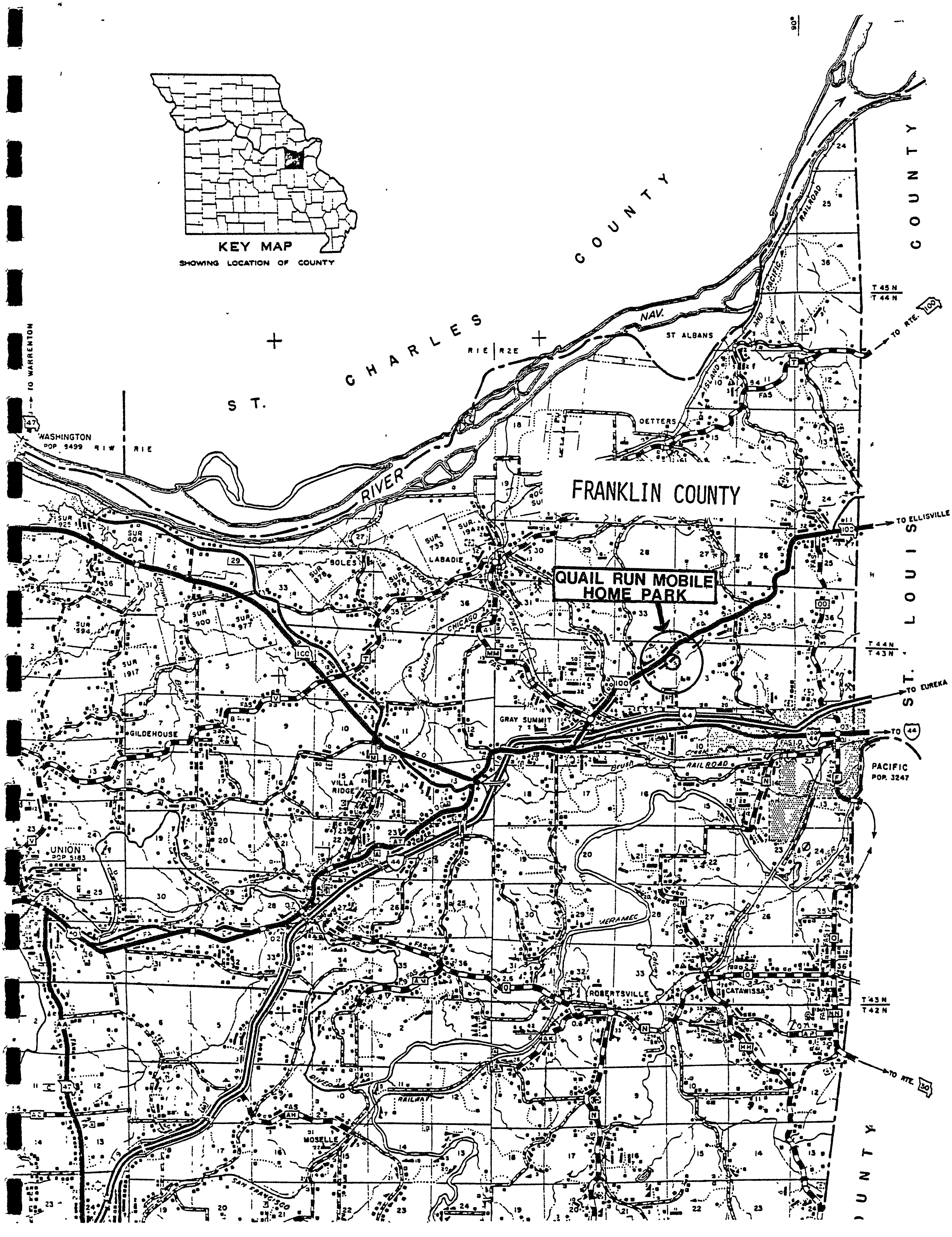
31. Baxter Garden Center:

This site is located off Wild Horse Creek Road in Chesterfield. The known concentrations of dioxin range up to 82 ppb. This site was oiled by Bliss in 1971. Even though this site is a commercial nursery, there is little, if any, public access to the contaminated area.

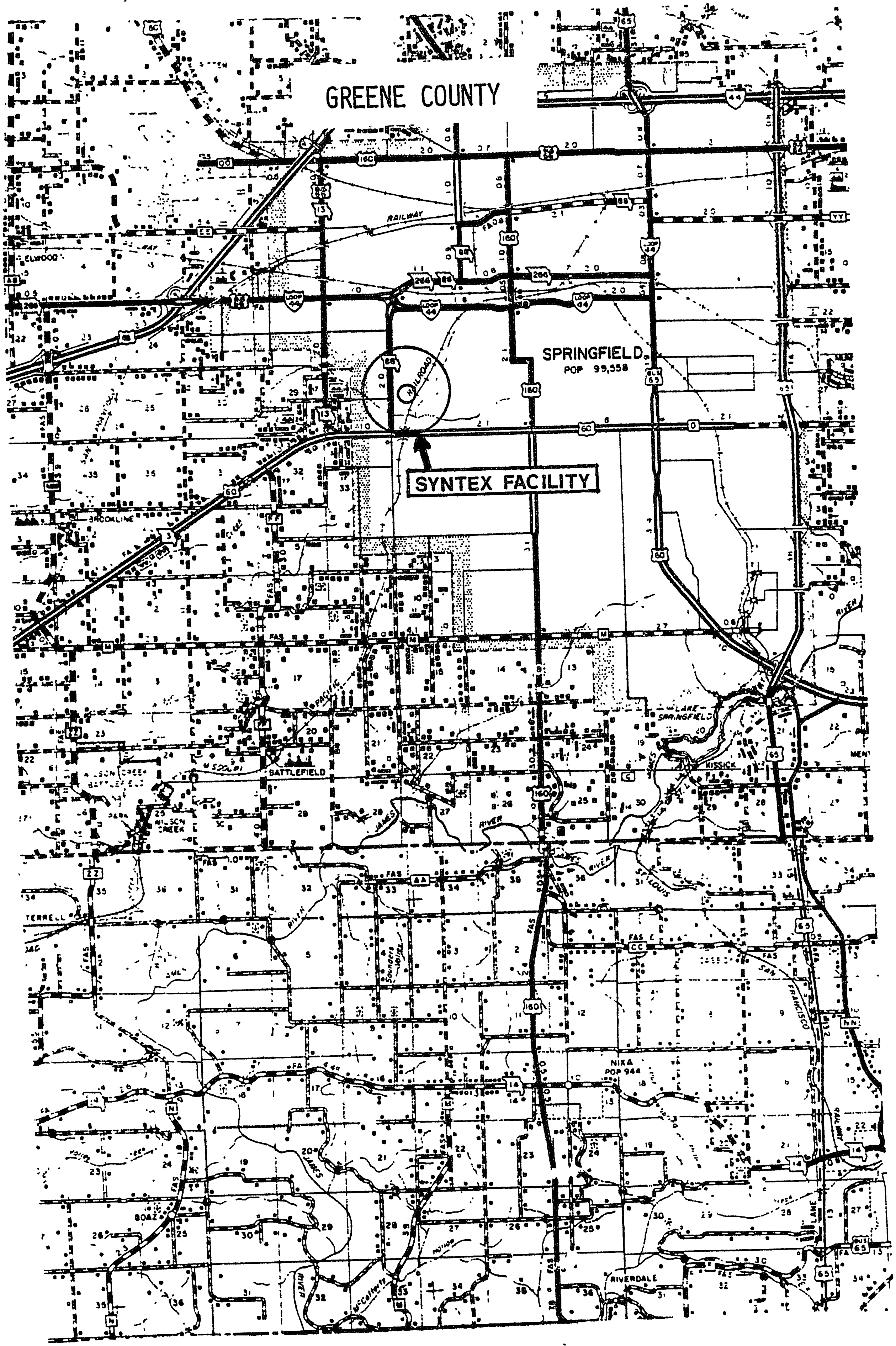


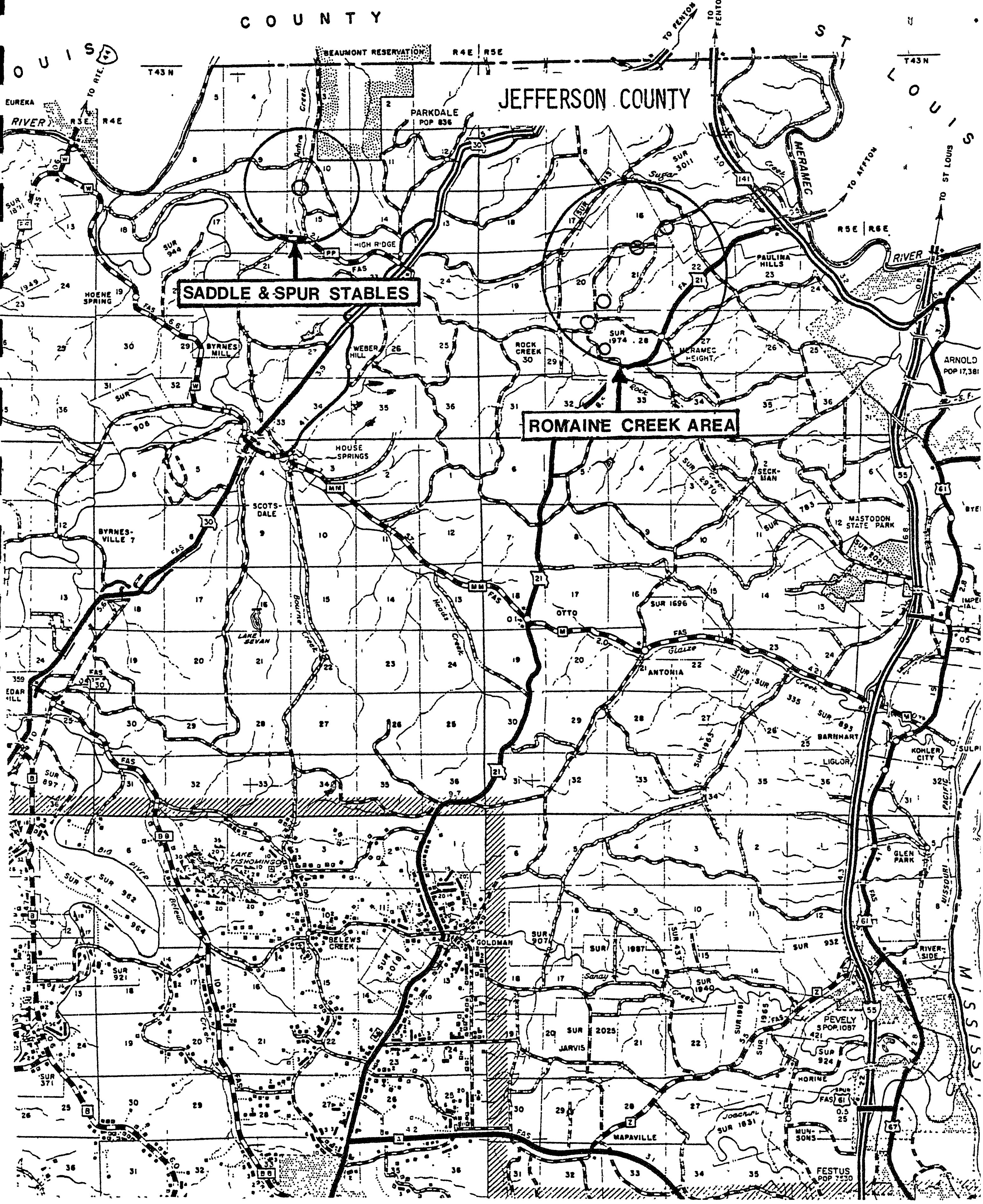
COUNTY
MONETT
POP. 5937
IN BARRY 4225
IN LAWRENCE 1712
TO VERONA
TO AURO
BARRY COUNTY
DENNEY FARM
CALTON MILL
PLEASANT RIDGE
MADRY
MCDOWELL
PURDY
POP. 588
LEANN
JENKINS
CLIO
STAR CITY
BUTTERFIELD
POP. 125
CATO
HAILEY
CASSVILLE
POP. 1910
MINERAL SPRING
HILL CITY
M A R K
T W A I
R 27 W
R 26 W
R 25 W


CALLAWAY COUNTY
TIMBERLINE STABLES
NEW BLOOMFIELD POP. 427
HOLTS SUMMIT POP. 2,318
CEDAR CITY POP. 454
JEFFERSON CITY
TO ASHLAND
CARRINGTON
GUTHRIE
DIXIE
LIBERTY
LAKE MYKEE
KRCG-TV
BOUGHNER
RENZ CORRECTIONAL CENTER
TEBBETTS
COTE SANS DESSEIN
WAINWRIGHT
BOONE COUNTY
COLE COUNTY
MISSOURI
OSAGE RIVER
T47N
T46N
T45N
T44N
R11W
R10W
R9W

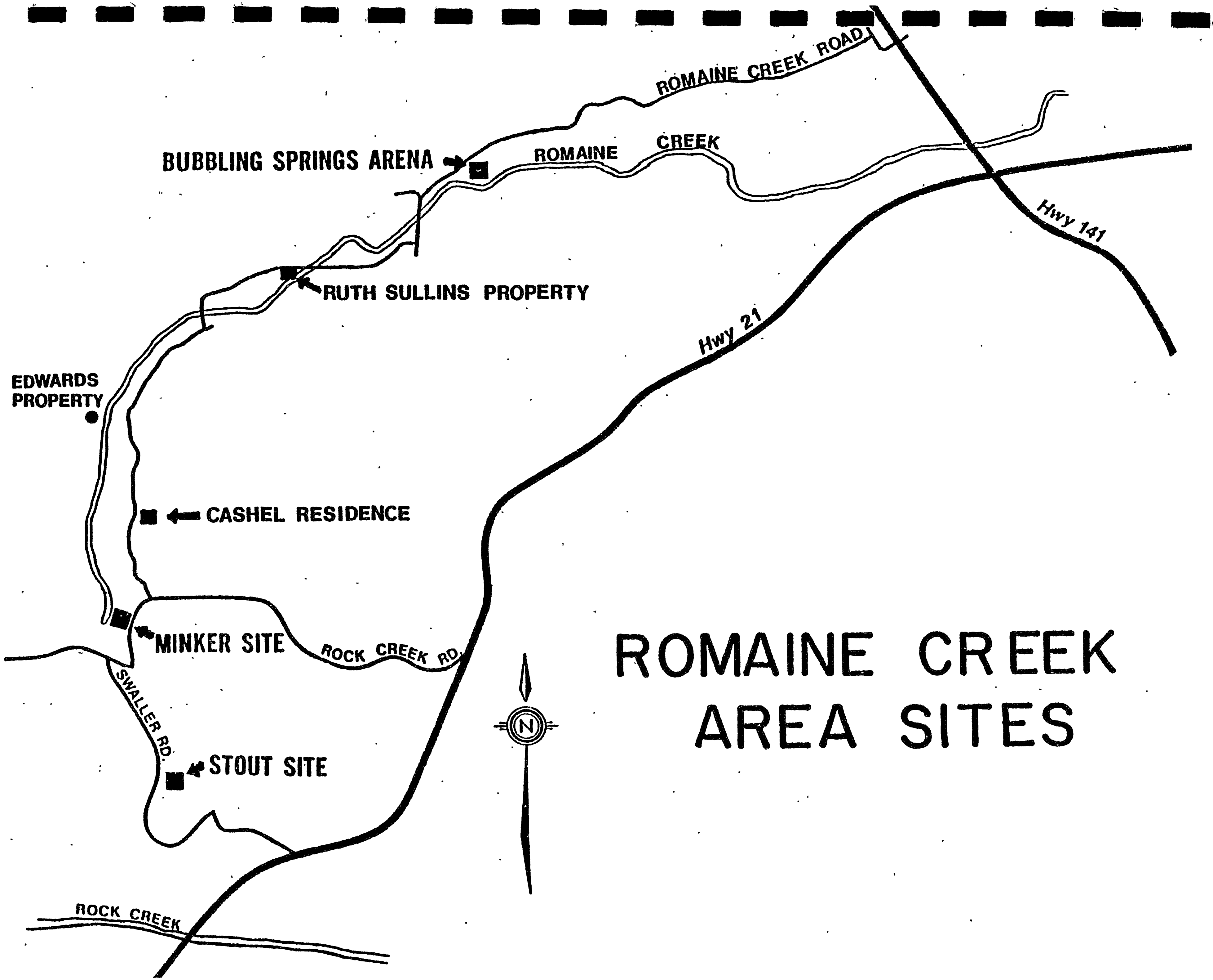


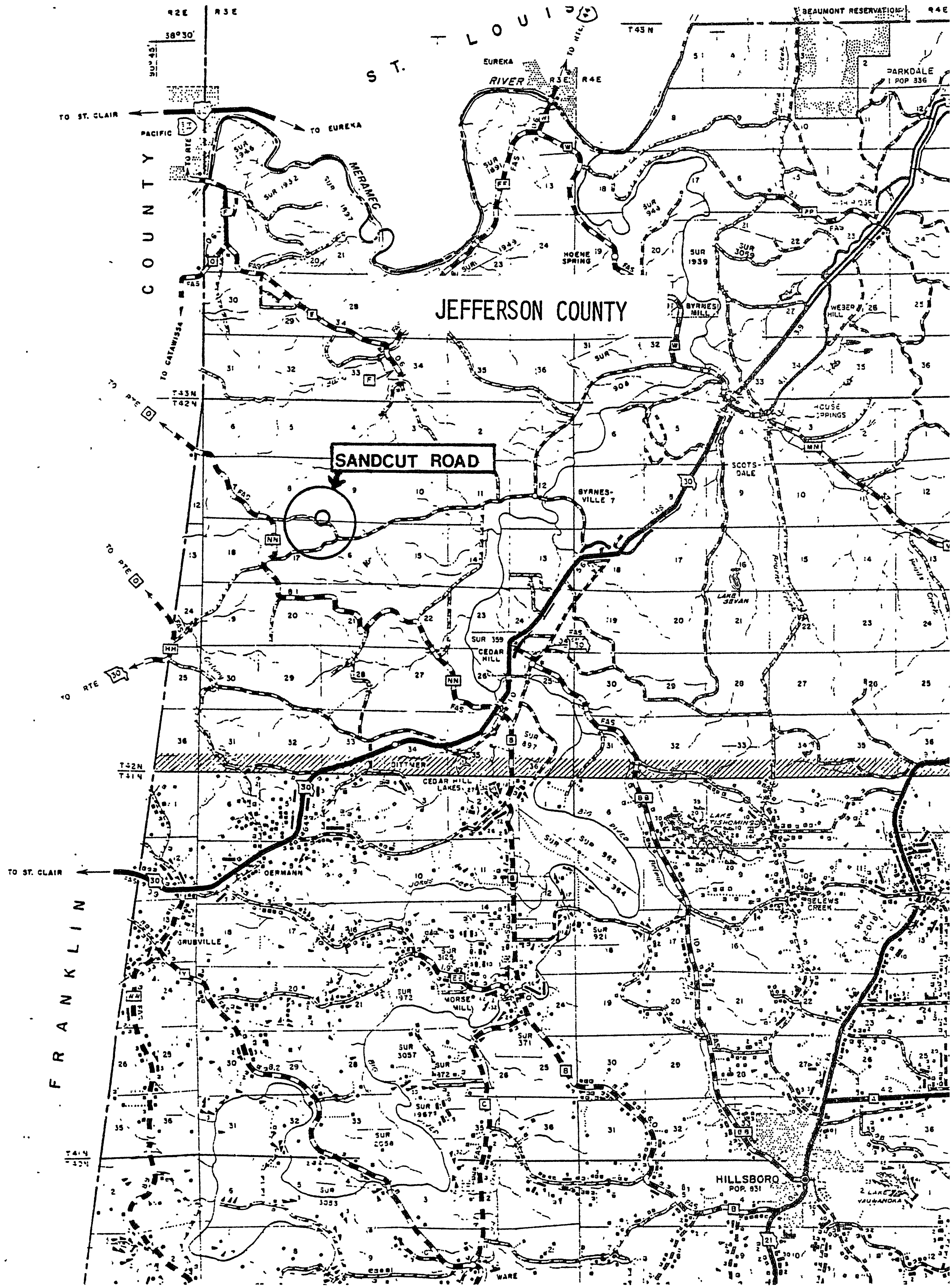
KEY MAP
SHOWING LOCATION OF COUNTY
FRANKLIN COUNTY
QUAIL RUN MOBILE HOME PARK
ST. CHARLES COUNTY
ST. LOUIS COUNTY
RIVER
NAV.
WASHINGTON POP. 9499
UNION POP. 5183
PACIFIC POP. 3247
ST ALBANS
OETTERS
LABADIE
BOLES
GILDEHOUSE
VILLA RIDGE
GRAY SUMMIT
ROBERTSVILLE
CATAWISSA
MOSELLE
TO WARRENTON
TO RTE. 100
TO ELLISVILLE
TO EUREKA
TO 44
TO RTE. 50
T 45 N
T 44 N
T 43 N
T 42 N
R1W R1E
R1E R2E
MERAMEC
BOURBEUSE
CHICAGO
PACIFIC
RAILROAD


GREENE COUNTY
SPRINGFIELD
POP 99,558
SYNTEX FACILITY
RAILROAD
RAILWAY
ELWOOD
BROOKLINE
BATTLEFIELD
WILSON CREEK
TERRELL
BOAZ
NIXA
POP 944
LAKE SPRINGFIELD
KISSICK
RIVERDALE
JAMES RIVER

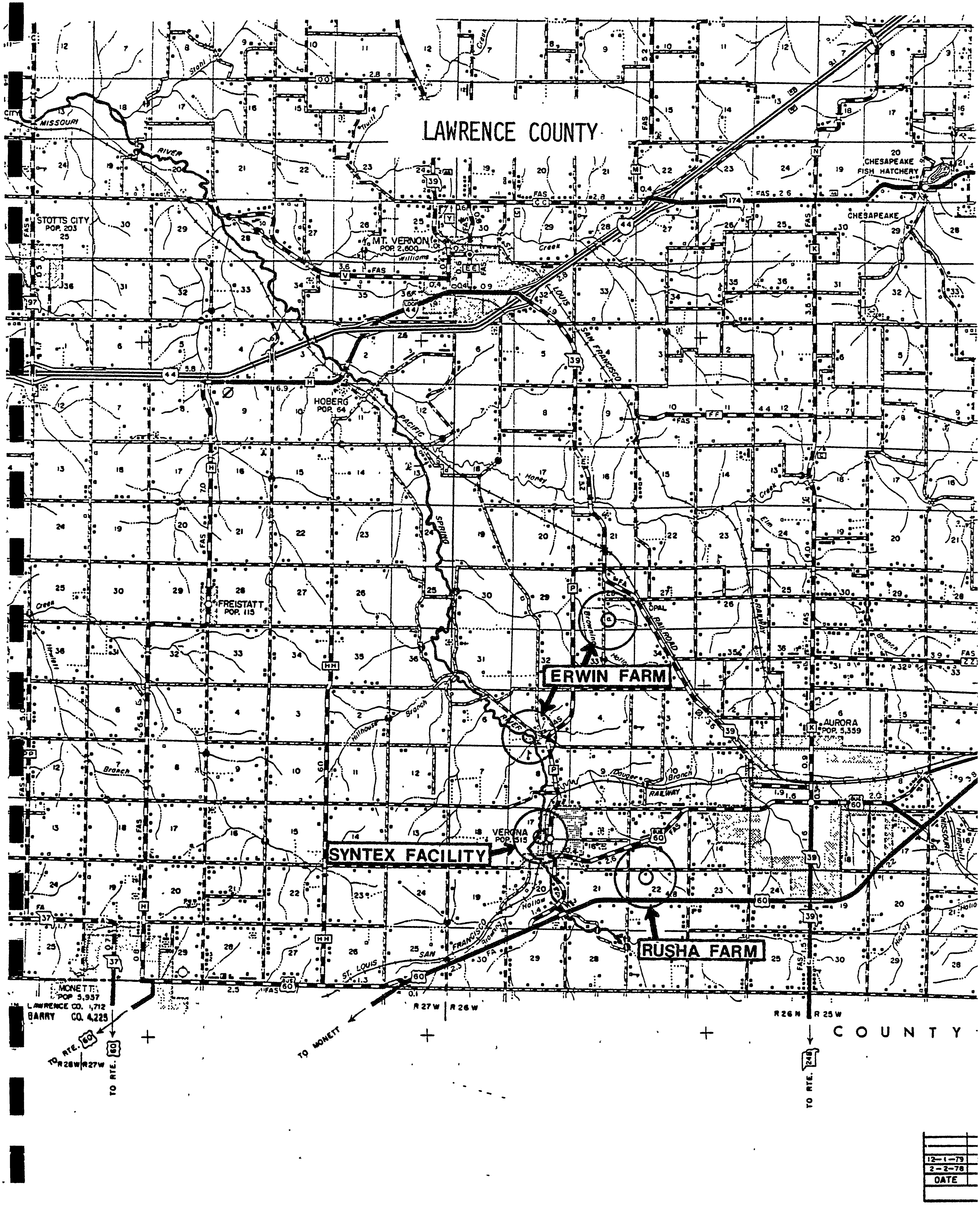


COUNTY
JEFFERSON COUNTY
SADDLE & SPUR STABLES
ROMAINE CREEK AREA
BEAUMONT RESERVATION
R4E
R5E
T43N
TO FENTON
TO AFFTON
TO ST LOUIS
TO RTE 44
EUREKA
RIVER
MERAMEC
PARKDALE
POP 836
HIGH RIDGE
HOENE SPRING
BYRNES MILL
WEBER HILL
ROCK CREEK
MERAMEC HEIGHT
PAULINA HILLS
ARNOLD
POP 17,381
HOUSE SPRINGS
SCOTSDALE
BYRNESVILLE
SECKMAN
MASTODON STATE PARK
OTTO
ANTONIA
LAKE SEVAN
BARNHART
KOHLER CITY
LIGUOR
LAKE TISHOMINGO
GLEN PARK
BELEWS CREEK
GOLDMAN
RIVERSIDE
PEVELY
POP 1087
JARVIS
HORINE
MAPAVILLE
MUNSONS
FESTUS
MISSOURI PACIFIC
MISSISS

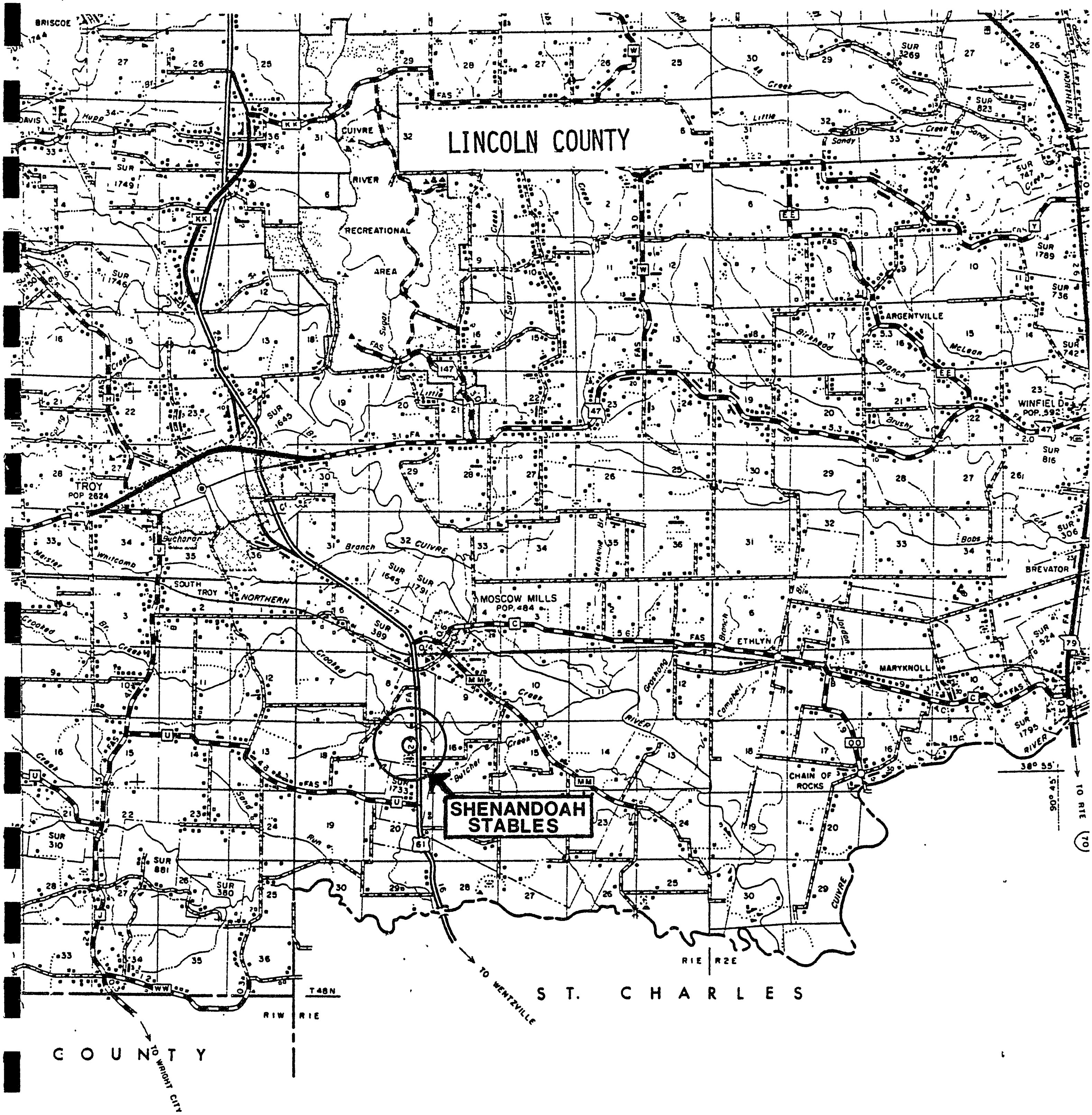

ROMAINE CREEK ROAD
BUBBLING SPRINGS ARENA
ROMAINE CREEK
Hwy 141
RUTH SULLINS PROPERTY
Hwy 21
EDWARDS PROPERTY
CASHEL RESIDENCE
MINKER SITE
ROCK CREEK RD.
SWALLER RD.
STOUT SITE
ROCK CREEK
N
ROMAINE CREEK
AREA SITES

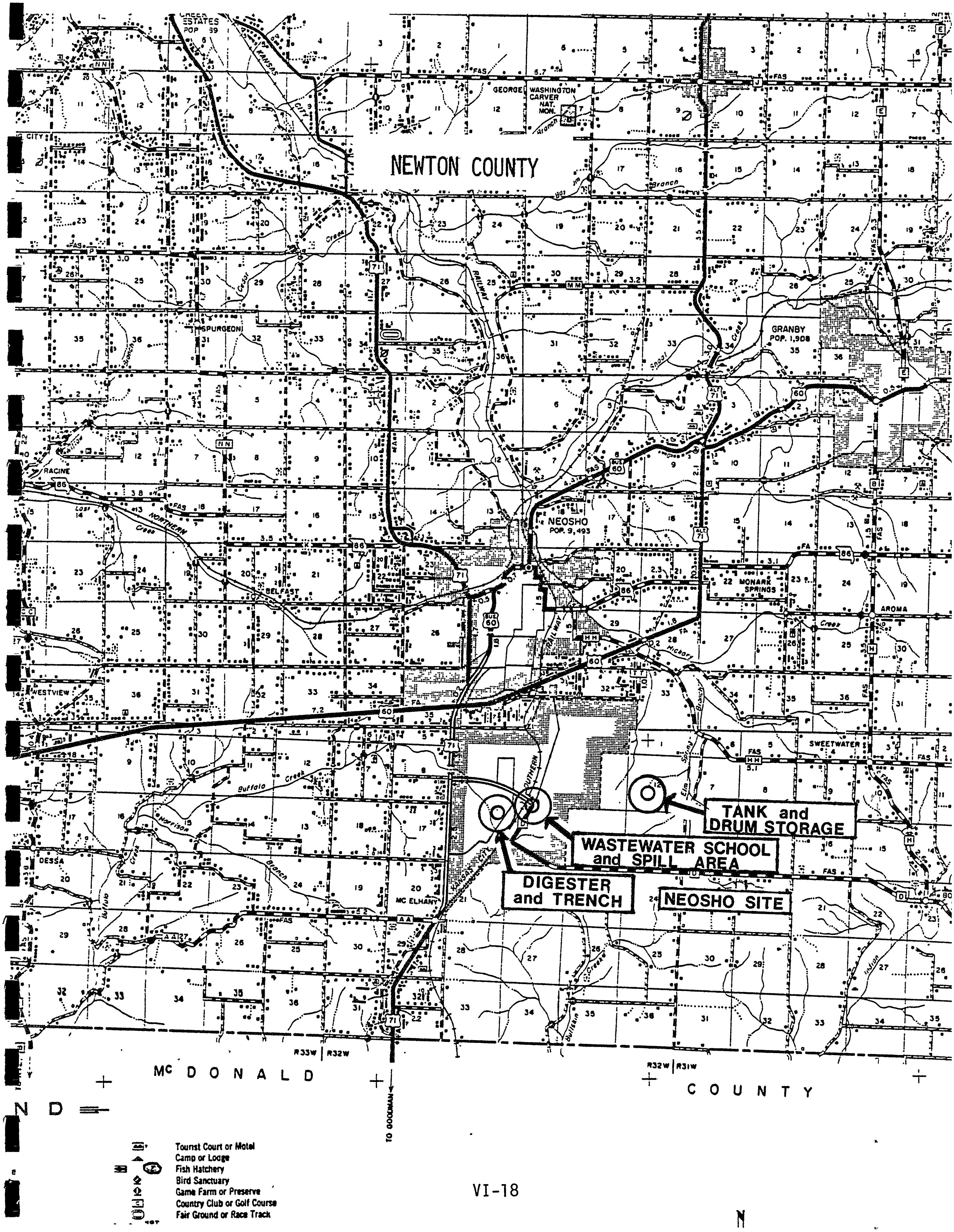


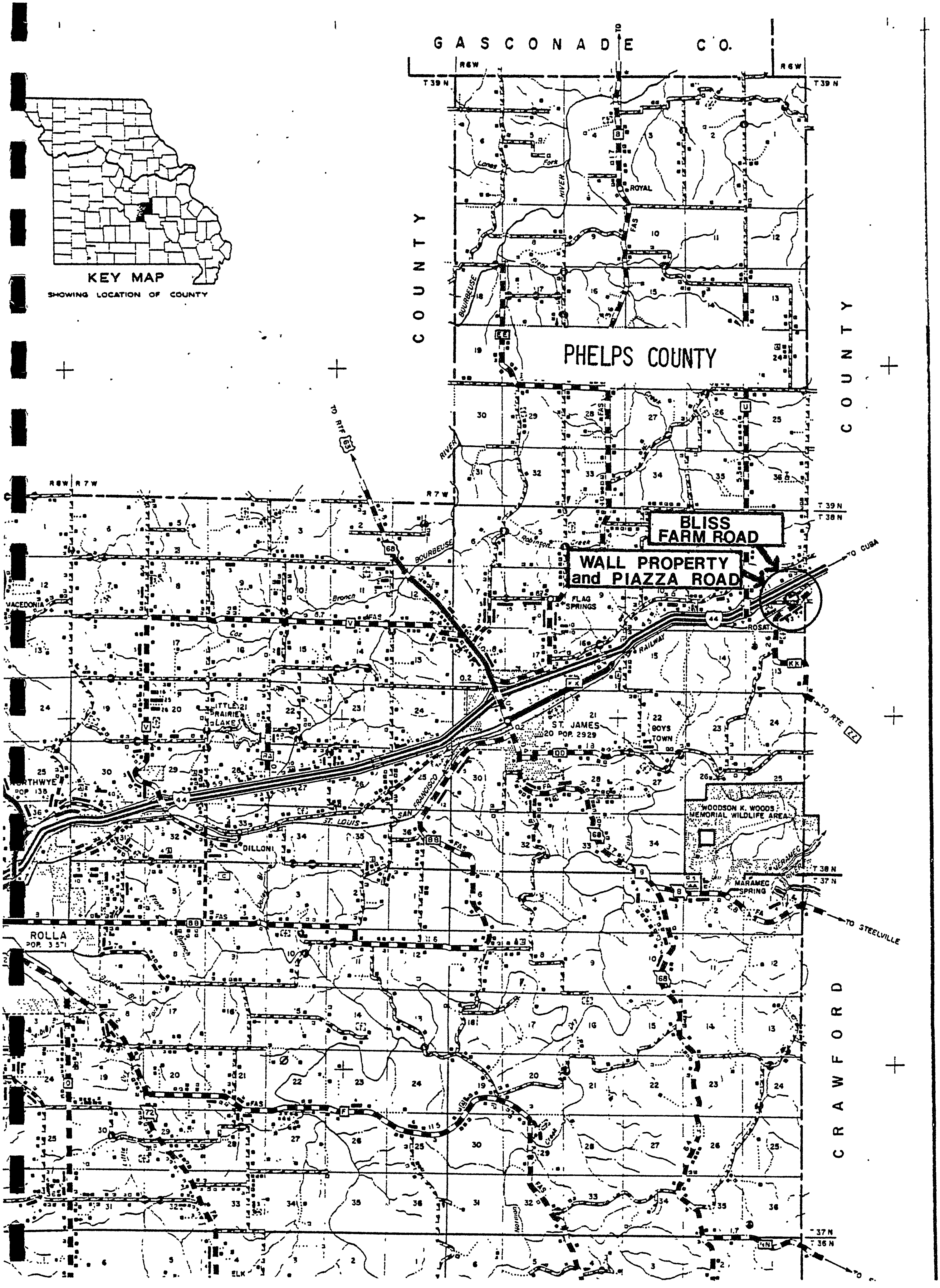
ST. LOUIS
COUNTY
FRANKLIN
JEFFERSON COUNTY
SANDCUT ROAD
TO ST. CLAIR
TO EUREKA
PACIFIC
EUREKA
MERAMEC
RIVER
BEAUMONT RESERVATION
PARKDALE
HOENE SPRING
BYRNES MILL
WEBER HILL
HOUSE SPRINGS
SCOTSDALE
BYRNESVILLE
CEDAR HILL
TO CATAWISSA
TO RTE O
TO RTE 30
DITTMER
CEDAR HILL LAKES
LAKE TISHOMINGO
BIG RIVER
GERMANN
GRUBVILLE
MORSE MILL
LAKE SEVAN
BELEWS CREEK
HILLSBORO
POP. 831
LAKE VAUWANOKA
WARE
T43N
T42N
T41N
R2E
R3E
R4E
38°30'



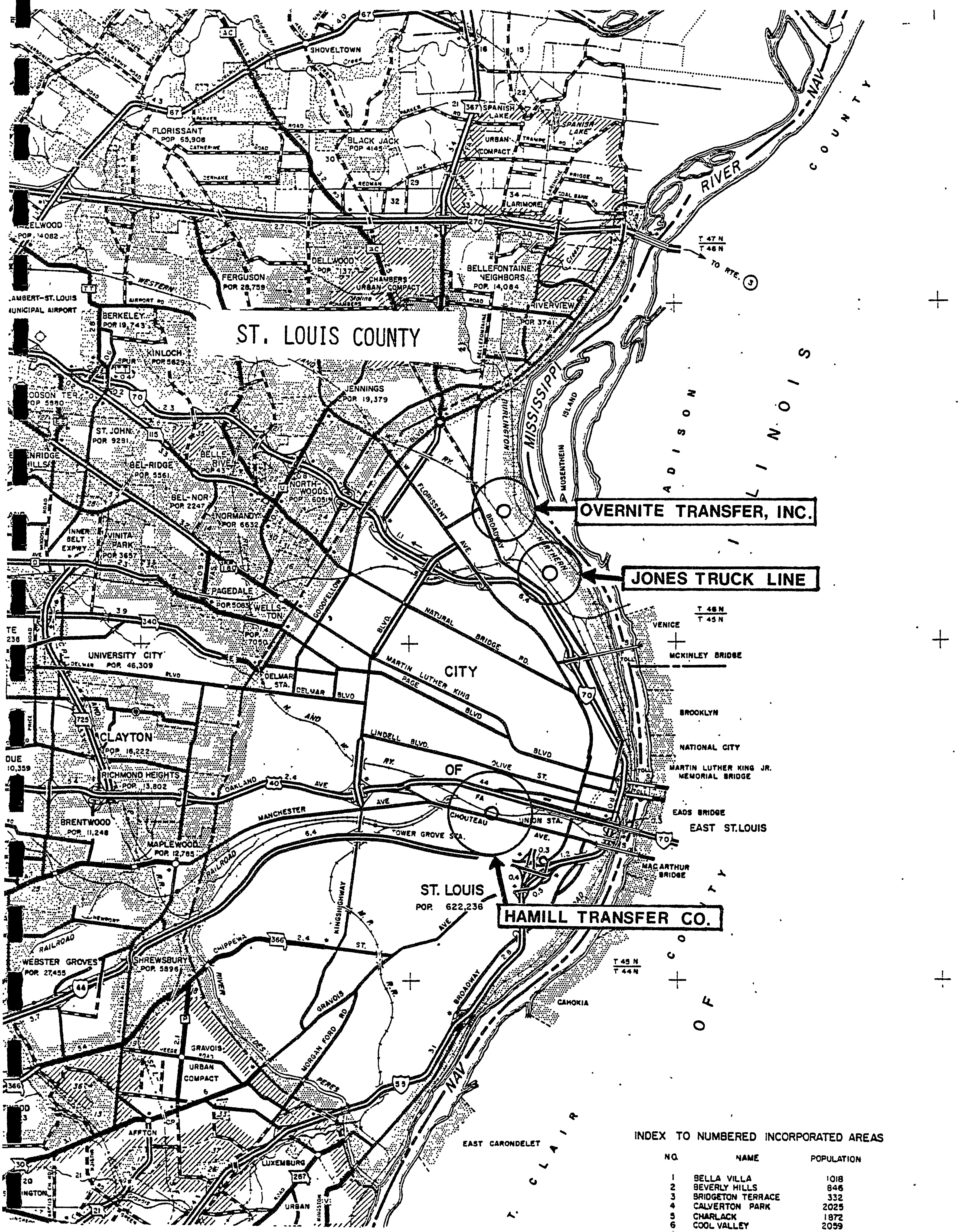
LAWRENCE COUNTY
STOTTS CITY POP. 203
MT. VERNON POP. 2,600
CHESAPEAKE FISH HATCHERY
CHESAPEAKE
HOBERG POP. 64
FREISTATT POP. 115
OPAL
ERWIN FARM
AURORA POP. 5,359
VERONA POP. 515
SYNTEX FACILITY
RUSHA FARM
MONETT POP. 5,937
LAWRENCE CO. 1,712
BARRY CO. 4,225
TO MONETT
R 27 W | R 26 W
R 26 W | R 25 W
R 28 W | R 27 W
COUNTY
12-1-79
2-2-78
DATE


LINCOLN COUNTY
RECREATIONAL AREA
TROY
POP 2624
SOUTH TROY
MOSCOW MILLS
POP. 484
ARGENTVILLE
WINFIELD
POP. 592
BREVATOR
ETHLYN
MARYKNOLL
CHAIN OF ROCKS
SHENANDOAH STABLES
TO WENTZVILLE
TO WRIGHT CITY
S T. C H A R L E S
C O U N T Y
CUIVRE RIVER
TO RTE 70


NEWTON COUNTY
GEORGE WASHINGTON CARVER NAT. MON.
NEOSHO POP. 9,493
GRANBY POP. 1,908
SPURGEON
RACINE
BELFAST
WESTVIEW
DESSA
MC ELHANY
MONARK SPRINGS
AROMA
SWEETWATER
TANK and DRUM STORAGE
WASTEWATER SCHOOL and SPILL AREA
DIGESTER and TRENCH
NEOSHO SITE
R33W | R32W
R32W | R31W
MC DONALD COUNTY
TO GOODMAN
Tourist Court or Motel
Camp or Lodge
Fish Hatchery
Bird Sanctuary
Game Farm or Preserve
Country Club or Golf Course
Fair Ground or Race Track


GASCONADE CO.
KEY MAP
SHOWING LOCATION OF COUNTY
PHELPS COUNTY
COUNTY
CRAWFORD COUNTY
BLISS FARM ROAD
WALL PROPERTY and PIAZZA ROAD
TO CUBA
ROSATI
FLAG SPRINGS
ST. JAMES
POP. 2929
BOYS TOWN
TO RTE ZZ
LITTLE PRAIRIE LAKE
NORTHWYE
POP. 138
MACEDONIA
DILLON
ROLLA
ROYAL
WOODSON K. WOODS MEMORIAL WILDLIFE AREA
MARAMEC SPRING
TO STEELVILLE
TO RTE 63
ELK
T 39 N
T 38 N
T 37 N
T 36 N
R 6 W
R 7 W

ST. LOUIS COUNTY
ST. CHARLES
SOUTHERN CROSS LUMBER CO.
BLISS OIL CO.
BAXTER GARDEN CENTER
MID-AMERICA ARENA
METHODIST CHURCH
SONTAG ROAD
TIMES BEACH CITY LIMITS
MISSOURI
RIVER
MERAMEC
HAZELWOOD POP. 14,082
LAMBERT-ST. LOUIS MUNICIPAL AIRPORT
EARTH CITY EXPWY
TO RTE. 61
CHAMP POP. 19
ST. ANN POP. 18,817
WOODSON TER. POP. 5880
MARYLAND HEIGHTS URBAN COMPACT
BRECKENRIDGE HILLS
OVERLAND POP. 24,949
CREVE COEUR
CREVE COEUR LAKE
BONHOMME ISLAND
VIGUS
FEE FEE
FERNRIDGE
HINE
LAKE
GUMBO
CHESTERFIELD
DANIEL BOONE
BELLEFONTAINE
OLIVETTE POP. 9238
CREVE COEUR POP. 10,660
WESTWOOD POP. 311
LADUE POP. 10,359
CLARKSON VALLEY POP. 157
FRONTENAC POP. 3920
BRENTWOOD POP. 11,248
TOWN AND COUNTRY POP. 2645
DES PERES POP. 5475
HUNTLEIGH POP. 714
WARSON WOODS POP. 2544
GLENDALE POP. 6981
ELLISVILLE POP. 4681
BALLWIN POP. 10,656
MANCHESTER POP. 5081
KIRKWOOD POP. 31,800
WEBSTER GROVES POP. 27,455
OAKLAND POP. 1609
WINCHESTER POP. 2329
TWIN OAKS POP. 41
MOUNTAIN RIDGE
CASTLEWOOD
FERN GLENN
VALLEY PARK POP. 3662
CRESTWOOD POP. 15,123
PALISADES
JEDBURG
TYSON
MORSCHELS
PEERLESS PARK POP. 51
BUDER PARK
SUNSET HILLS POP. 4120
SAPPINGTON
WASHINGTON UNIVERSITY RESEARCH CENTER
CRESCENT
DEICKE
FENTON POP. 2275
CONCORD VILLAGE
TIMES BEACH POP. 1265
BEAUMONT RESERVATION
TO ST. CLAIR
R4E R5E
R3E R4E



INDEX TO NUMBERED INCORPORATED AREAS

NO.	NAME	POPULATION
1	BELLA VILLA	1018
2	BEVERLY HILLS	846
3	BRIDGETON TERRACE	332
4	CALVERTON PARK	2025
5	CHARLACK	1872
6	COOL VALLEY	2059

APPENDIX VII

SUMMARY OF INFORMATION PRESENTED TO THE TASK FORCE BY CH_2M-HILL*

Remedial Action Alternatives Being Considered

Over 50 possible treatment processes and over 500 sources of information were considered in the initial screening of remedial alternatives. The treatment processes shown on Figure 5-2 were screened on the basis of 1) state of development, 2) health and safety risks, 3) process complexity and constructability, 4) reliability, and 5) cost to arrive at six alternatives for further detailed analysis.

The remedial alternatives shown on Figure 5-3 are currently under evaluation for the Minker/Stout site. Five of these alternatives are technically feasible, reliable, and can effectively mitigate the risk to public health, welfare, and the environment with the use of today's technology, while the sixth depends on emerging technology. Alternatives A through C rely on the principal of containment to reduce dioxin exposure which, due to the demonstrated insoluble nature of dioxin in these soils, center around immobilizing the contaminated soil particles. Alternatives D through F rely on the principal of treatment to reduce dioxin level, in addition to containment of the treatment residue.

At this time, no sites have been identified for siting a hazardous waste management facility; therefore, EPA has directed that, for purposes of this study, the Minker site be the assumed location. The socioeconomic, political, and demographic impacts on the community resulting from the siting of such a facility are well beyond the scope of the feasibility study and will not be considered at this time.

Other remedial alternatives are possible and may be considered for other sites, or as a part of an overall Missouri Dioxin Feasibility Study.

Alternative A

This alternative would secure the soil in-place, prevent public site access, and establish a hazardous waste landfill at each fill area. This would likely involve insitu soil fixation and securing of the site with a subsurface perimeter grout curtain, an impermeable cap over the contaminated area, and diversion of surface runoff. Permanent resident relocation and house demolition would be necessary at the sites, and for additional households inside a buffer zone. A long-term site monitoring and maintenance program would be implemented to monitor the groundwater and surrounding environment.

Alternative B

This alternative includes removing the contaminated soil and consolidating into one area on the Minker site. Due to the very shallow soil depth, unsuitable site hydrogeology, and the need for a positve liner and leachate collection system, an above-grade concrete vault would contain the contaminated

*CH_2M-Hill is a consulting engineering firm contracted by EPA to do the feasibility study for remedial action at the Minker/Stout site.

soil. Permanent resident relocation and house deomolition would be necessary at the sites, and for additional households inside a buffer zone. A long-term site monitoring and maintenance program is also required.

Alternative C

This alternative involves removing and transporting the contaminated soil to a secure hazardous waste landfill for disposal. Two potentially acceptable landfill sites have been located within a 600-mile radius of Minker/Stout. Per the April 3, 1983, Federal Register, EPA is currently considering the addition of dioxin wastes to RCRA regulations. If this proposed rule is promulgated, the design and operation of each landfill disposal facility will need to be thoroughly evaluated before dioxin can be added to their permit.

The removed soil volume and up to 2 feet of additional fill would be added to restore the site drainage and to cover any fugitive trace of contaminated soil. The site would be relandscaped and the houses rehabilitated, thus enabling the complete restoration of the area.

Alternative D

This alternative involves the direct thermal destruction of dioxin-bound soil. The contaminated soil would be removed to a concrete vault, where it would remain while the incineration process is pilot tested and developed for this particular contaminated soil. A significant permitting effort may be necessary for the siting of a full-scale facility. Following the permitting process and the construction of the facility, the soil would be transported to a size reduction and handling process, and then to an incinerator. The incinerator particulate and soil residue would be transported to a secure landfill site, unless extensive testing is able to prove them free of TCDD contamination.

The removed soil volume and up to 2 feet of additional fill would be added to restore the site drainage and to cover any trace of contaminated soil. Locating the storage vault and incinerator offsite would enable the area to be relandscaped and the houses rehabilitated, thus enabling the restoration of the area.

Alternative E

This alternative involves extracting the dioxin from the soil with a solvent, concentrating the solvent, and then destroying the dioxin in the solvent. The contamiated soil would be removed to a concrete vault, where it would remain while the solvent extracted process is pilot tested and developed for this particular contaminated soil. A significant permitting effort may also be necessary for the siting of a full-scale facility. Following the permitting process and the construction of this process, the soil would be transported to a size reduction and handling process, and then to the solvent extraction process. The resulting contaminated solvent would be concentrated, with the concentrate undergoing degradation and incineration. The incinerator particulate and the soil residue would be sent to a secure landfill site, unless extensive testing is able to prove them TCDD-free.

The removed soil volume and up to 2 feet of additional fill would be added to restore the site drainage and to cover any trace of contaminated soil. Locating the storage vault, solvent extraction process, and the incinerator offsite would enable the area to be relandscaped and the houses rehabilitated, thus enabling the restoration of the area.

Alternative F

This alternative allows for the development of emerging technologies. The contaminated soil would be removed and stored until such time that emerging technologies such as supercritical water reactors, wet air oxidation, and biological degradation are pilot tested and evaluated for their ability to be competitive with existing technology. Today, these emerging technologies are not considered to be commercially developed for this type of hazardous waste and each has several major technical hurdles to overcome. There is a risk that the emerging technologies may never become cost-effective for this waste and, therefore, a contingency plan will be necessary, should the research and development program not proceed as quickly as planned or is unable to demonstrate on acceptable alternate technology.

The prediction of the timetable for Minker/Stout remedial action is difficult due to unpredictable variables such as site hydrogeologic problems, technical difficulties which may arise during process development, permitting delays, design problems, bidding periods, construction delays, extended public comment periods, and possible legal intricacies. Based on the key assumption that none of these variables will pose an abnormal project delay, the following minimum schedules have been discussed for the completion of the remedial alternatives and the restoration of the site. Onsite remedial activities are only a small portion of the total required schedule.

Alternative	Minimum Total Schedule	Remedial Action
A	3 years	1 year
B	3 years	1 year
C	2-1/2 years	1/2 year
D	8 years	3 years
E	11 years	3 years

Remedial Action Costs

The following comparative cost estimate (+50, -30 percent accuracy) was established for 5,000-8,000 cubic yards of contaminated soil from the Minker/Stout site. This volume estimate is in the process of being revised to reflect the latest increases in the Stout area of contamination.

The estimated costs are intended to be inclusive of all of the direct and indirect costs associated with a particular remedial action for Minker/Stout. The enclosed figure, "Comparison of Costs Included in Remedial Alternatives," indicates a typical scope of what is included in the cost estimate. Many of the costs are highly site-specific for the difficult conditions at the Minker/Stout site and may not apply to any other site.

	Estimated Cost ($ Millions)	
Alternative	5,000 yd^3	8,000 yd^3
A	29	30
B	9	11
C	4 1/2	8
D	29	38
E	57	77

We are in the process of refining the basis of these estimated costs and to incorporate the data received since our March 30 presentation. At this time, it appears that the requirements for size reduction and solvent incineration may be significantly reduced from these initial estimates. Because of this, the capital cost of Alternatives D and E may be reduced by as much as 20 percent over the initial estimates.

The estimated costs are prepared for guidance in project evaluation and implementation from the information available at the time. The final costs of the remedial action will depend on actual labor and material costs, competitive market conditions, final scope, levels of personnel protection and decontamination, implementation schedule, and other variable factors. As a result, the final project estimate and actual implementation cost will vary from the estimates presented.

Process/Technology	Description	Fate of Dioxin
FIXATION		
1. Organic polymer	Soil containing TCDD is mixed with an organic polymer which hardens.	TCDD and soil are bound together
2. Inorganic with cement, fly ash, or ceramic	Soil containing TCDD is combined with portland cement or fly ash. Moisture is added as required to cause the mixture to set.	TCDD and soil are boun(together
3. Carbon	Soil containing TCDD is mixed with activated carbon. Free or uncomplexed TCDD is adsorbed on the carbon	TCDD in soil and TCDD on carbon are mixed together
4. Encapsulation	Soil containing TCDD is enclosed in a barrier of low permeability such as high density polyethylene	TCDD and soil are enclos
SECURE IN PLACE	Securing the site and capping with bentonite clay	TCDD remains on-site in secured location
IN-SITU DEGRADATION		
1. Ultraviolet degradation	A suitable hydrogen donor (preferably non-toxic and non-volatile) is applied to the soil followed by irradiation with sunlight or high-pressure mercury lamps.	Soil remains in place; TCDD is degraded; TCDD may be spread by the solvent.
2. Chemical degradation	A chloroiodide micellar solution is applied to the soil and the ether bonds of the TCDD are cleaved.	Soil remains in place; TCDD is degraded
EXTRACTION		
1. Solvent	Soil is processed to enable extraction with solvent and then TCDD is extracted from soil with solvent in either a batch or continuous operation.	TCDD in solvent
2. Steam stripping	TCDD is volatilized from soil by contacting with steam.	TCDD with water as insolu phase
CONCENTRATION		
1. Adsorption, carbon	Solvent containing TCDD is passed through activated carbon	TCDD is adsorbed on carb(
2. Adsorption, resin	Solvent containing TCDD is passed through resin.	TCDD is absorbed on resin
3. Distillation	Solvent is distilled and TCDD is concentrated in the distillation bottoms.	TCDD in distillation bottom
4. Membrane processing	Selective passage of solvent through a membrane, as in reverse osmosis or ultra-filtration.	TCDD concentrated in solvent

	Byproducts	Commercial Status	References
	None	Used routinely on commercial scale for soil; no TCDD experience	
	None	Used routinely on commercial scale for soil; no TCDD experience	
	None	Conceptual	
ed	None	Commonly used for encapsulation of hazardous waste	
	None	Demonstrated on industrial scale	
	Soil contains TCDD decomposition products	Tried at Seveso with limited success	
	Soil contains TCDD decomposition products	TCDD in a 100g sample of Seveso soil has been 52% degraded in a laboratory test	
	Soil containing solvent	Bench-scale experience only with soil but commercial experience with sludge from distillation bottoms at Verona	
uble	Possible TCDD thermal decomposition products	Conceptual	
bon	TCDD free solvent	Pilot testing on herbicide orange	
n	TCDD free solvent	Laboratory tested to remove pesticides from wastewater; conceptual only for TCDD	
ms	TCDD free solvent	Commercially used in pesticide manufacturing process; also done at Verona	
	TCDD free solvent	Conceptual	

TABLE 5-1
DIOXIN
PROCESS/TECHNOLOGY
SUMMARY

Process/Technology	Description	Fate of Dioxin
DEGRADATION		
1. Radiation treatment		
a. UV degradation	TCDD is irradiated with sunlight or high pressure mercury lamps in the presence of a suitable hydrogen donor after solvent extraction from soil. TCDD in solvent is irradiated with gamma radiation.	TCDD degradation
b. Gamma	TCDD in solvent is irradiated with gamma radiation.	TCDD degradation
2. Chemical Treatment		
a. Catalytic dechlorination	TCDD in solvent is dechlorinated with Nickel Borohydride catalyst.	TCDD degradation
b. Chlorination	TCDD in solvent is extensively chlorinated between 600 and 800° C and 150 psig.	TCDD degradation
c. Ruthenium tetroxide	TCDD in solvent is oxidized with ruthenium tetroxide	TCDD degradation
d. Chloroiodides	TCDD is reacted with chloroiodides in a micellar solution	TCDD degradation
e. Ozone/UV	TCDD in solvent is reacted with ozone and irradiated with ultraviolet light.	TCDD degradation
f. Chemical dechlorination	TCDD is reacted with an aromatic liquid and alkaline reactants.	TCDD degradation
3. Thermal Treatment		
a. Wet air oxidation	TCDD is catalytically oxidized at 200° C in a wet air oxidation process.	TCDD degradation
b. Conventional hazardous waste incineration	TCDD in soil or solvent is combusted in a hazardous waste incinerator.	TCDD degradation
c. Molten salt combustion	TCDD in solvent is injected below the surface of a molten salt bath in a reactor at 1500° F to 1800° F	TCDD degradation
d. Microwave-plasma destruction	TCDD in soil or solvent is mixed with partially ionized gas produced by microwave-induced electron reactions.	TCDD degradation
e. Pyrolysis	TCDD in soil or solvent is decomposed by heat alone.	TCDD degradation

Byproducts	Commercial Status	References
Solvent with TCDD decomposition products	Commercially done at Verona	
Solvent with TCDD decomposition products	Laboratory tests on TCDD in solvent	
Solvent with TCDD decomposition products	Conceptual	
Solvent with TCDD decomposition products of CCl_4, HCL, and $COCl_2$	Piloted on herbicide orange	
Solvent with TCDD decomposition products	Laboratory tests only	
Solvent with TCDD decomposition products	Laboratory tests only	
Solvent with TCDD decomposition products	Laboratory tests only	
Solvent with TCDD decomposition products	Laboratory tests only	
TCDD decomposition products	Laboratory tests with TCDD	
TCDD decomposition products	Commerical incineration available for PCB's, other hazardous wastes; TCDD incinerated with herbicide orange on the M/T Vulcanus	
TCDD decomposition products; spent molten salt melt	Laboratory tests with chlorinated hydro-carbons	
TCDD decomposition products	Pilot-scale tested on PCB's and other toxic products materials	
TCDD decomposition products	Conceptual	

TABLE 5-1 (continued)
DIOXIN
PROCESS/TECHNOLOGY
SUMMARY

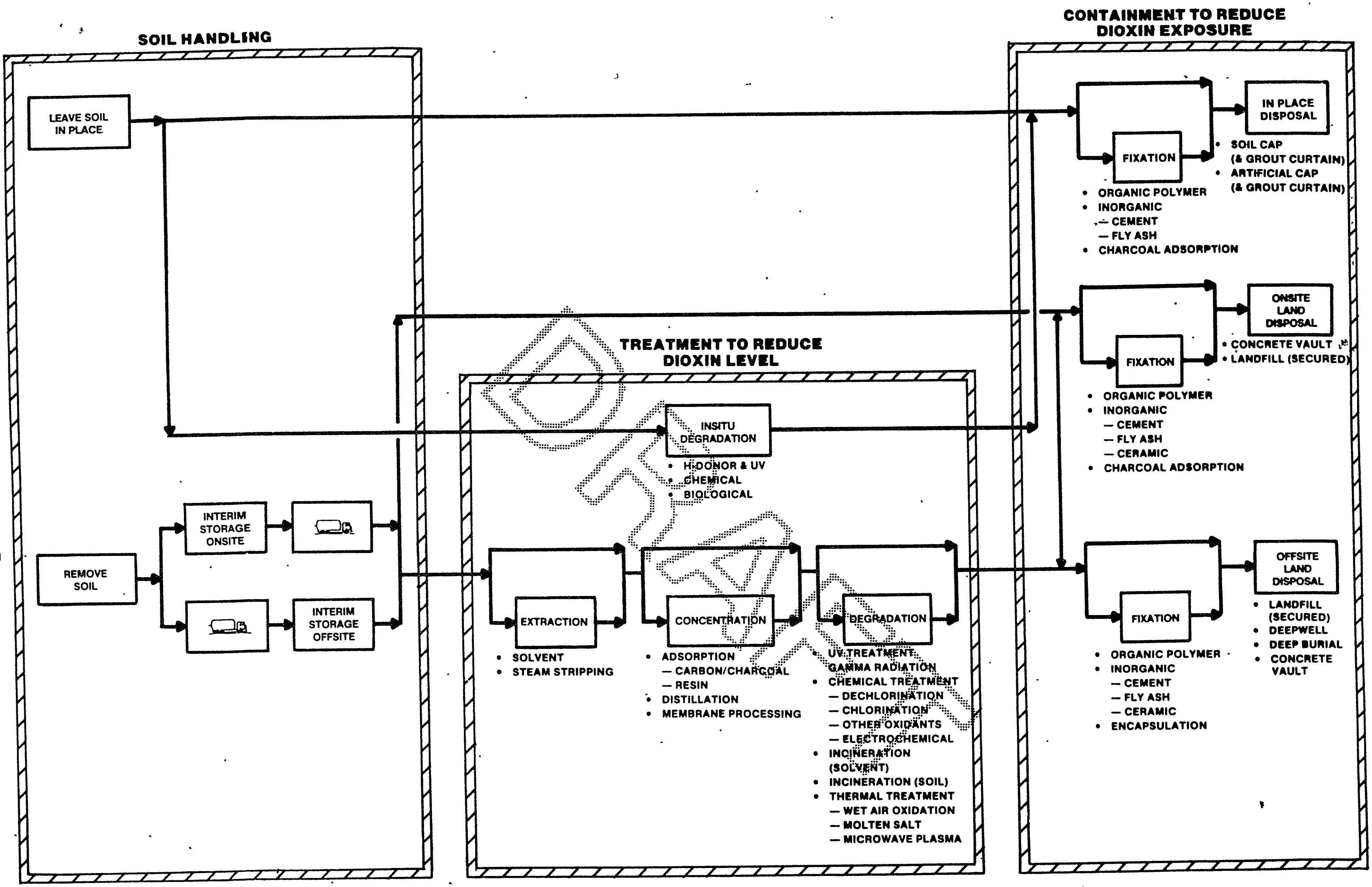


FIGURE 5-2
REMEDIAL ACTION APPROACHES
MINKER/STOUT

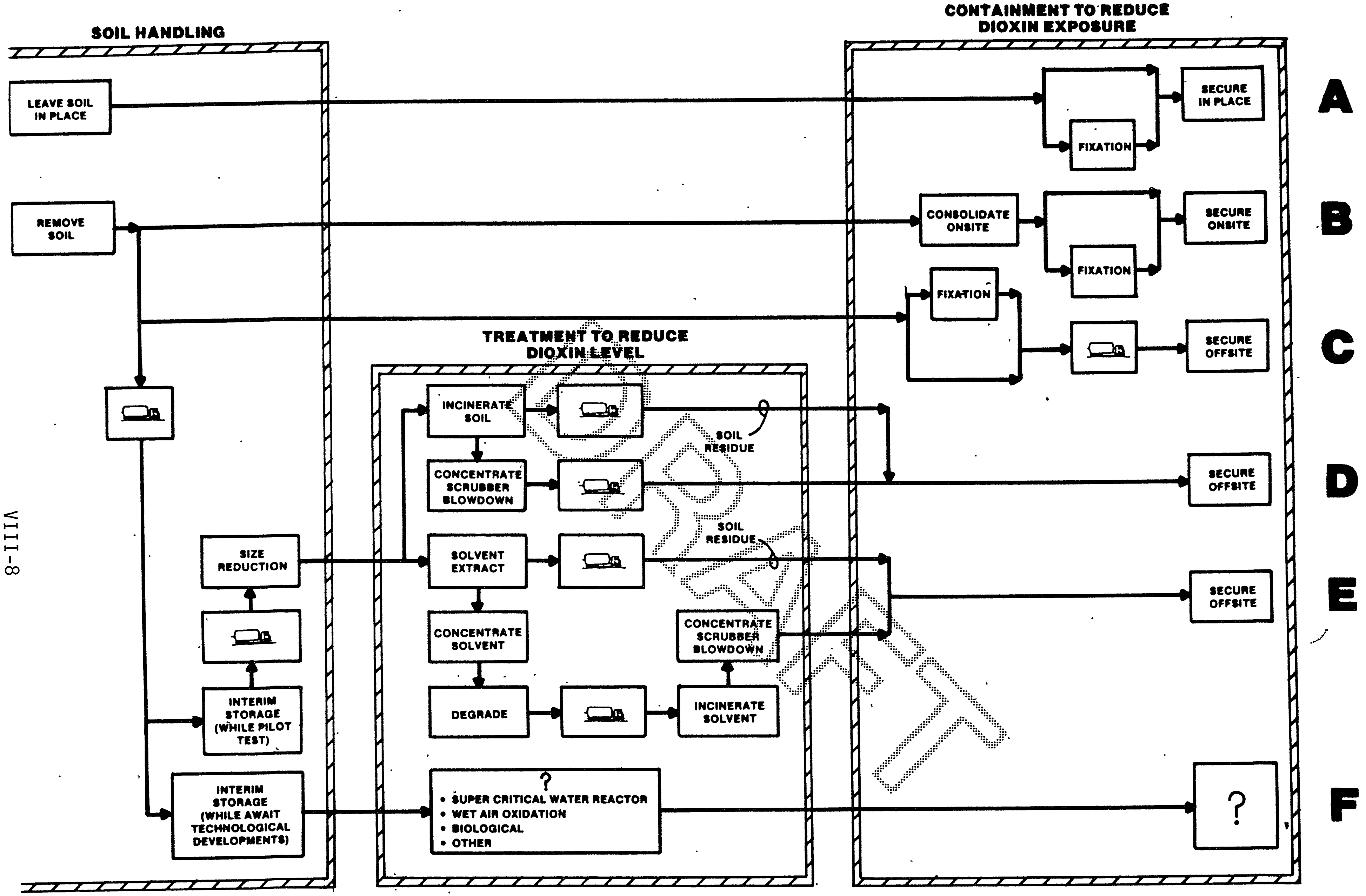


FIGURE 5-3
REMEDIAL ACTION ALTERNATIVES
MINKER/STOUT

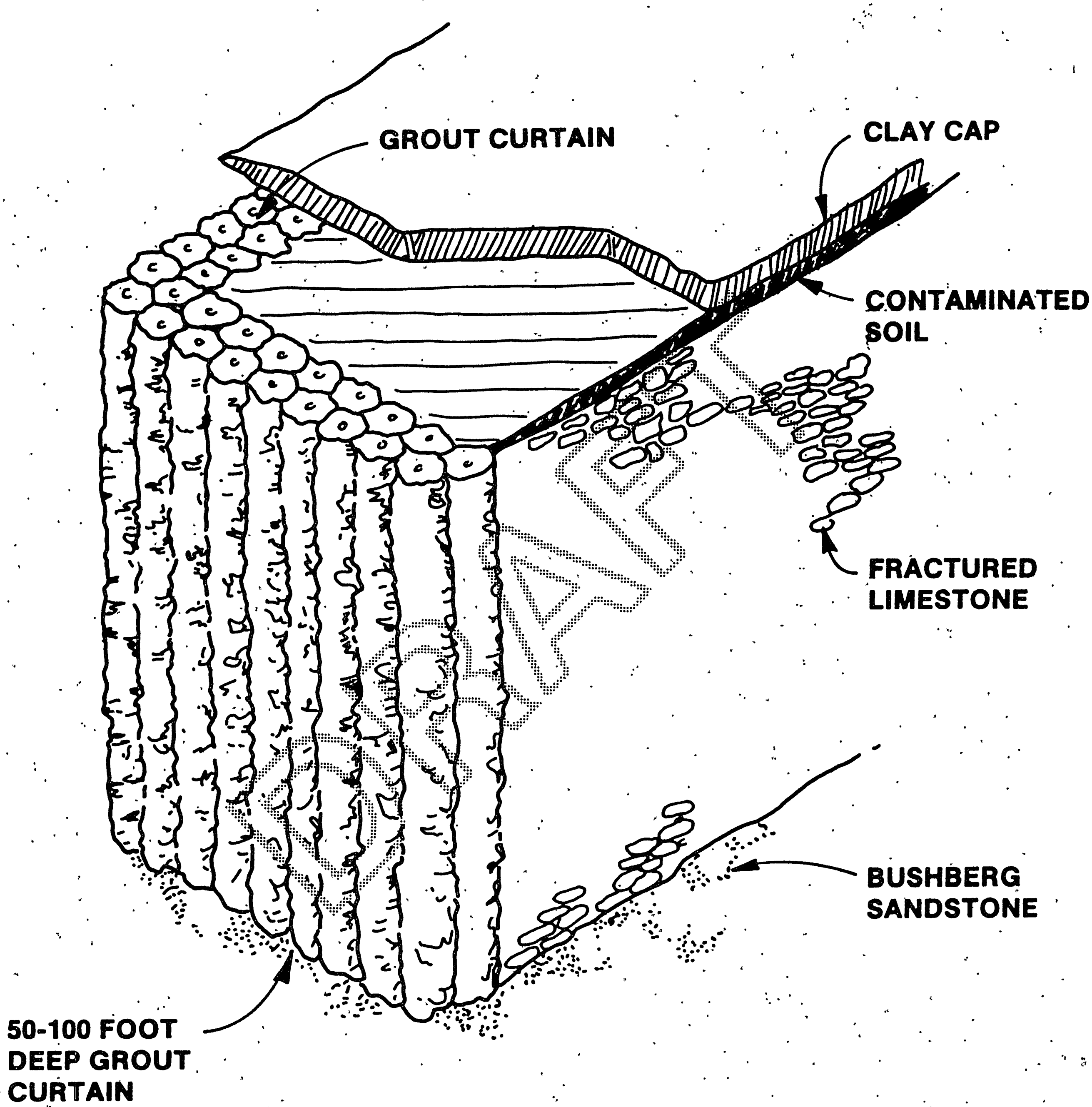


FIGURE 5-4
SECURE IN PLACE (ALTERNATIVE A) CONCEPTUAL DIAGRAM

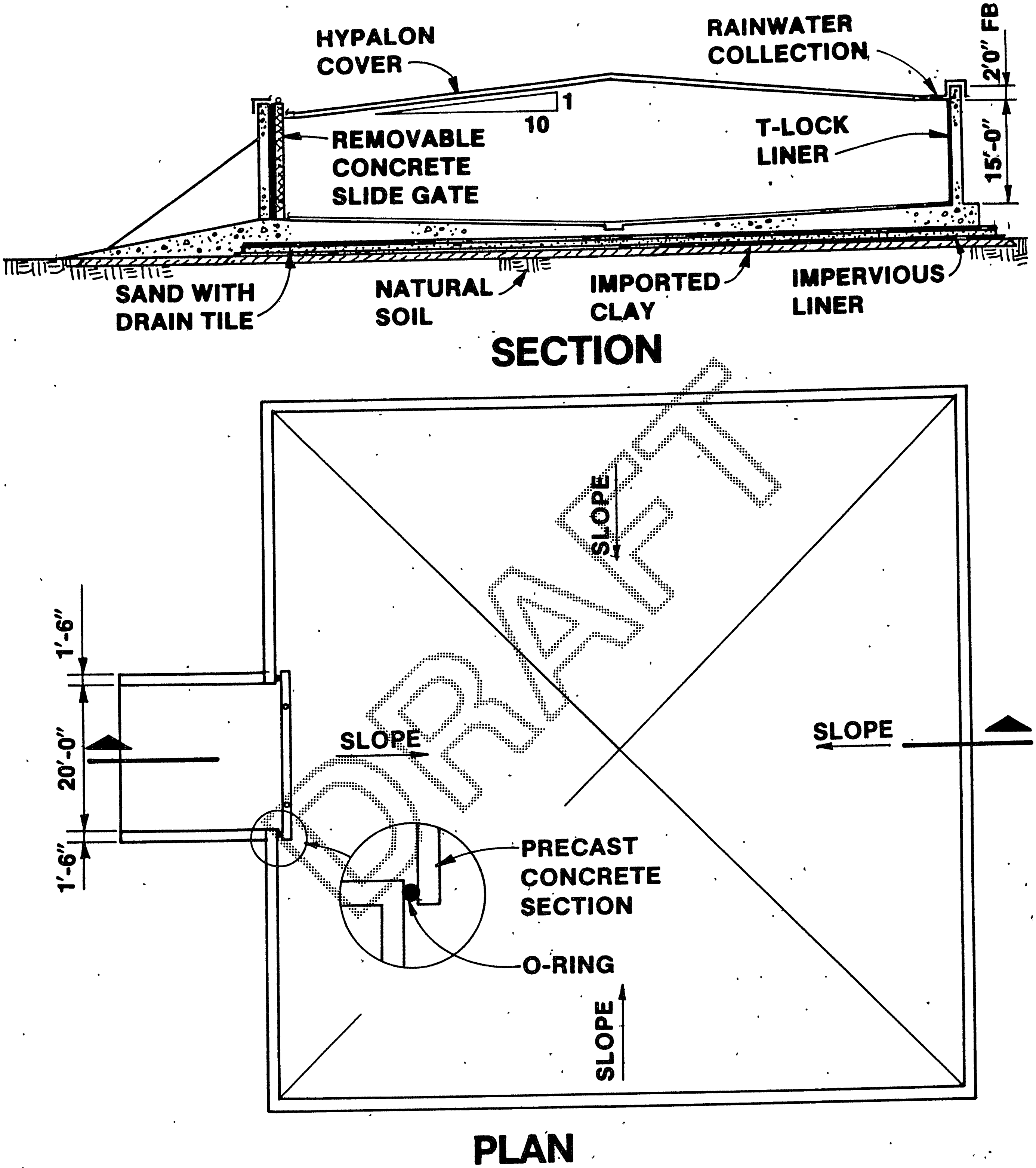


FIGURE 5-5
ABOVEGROUND STORAGE VAULT

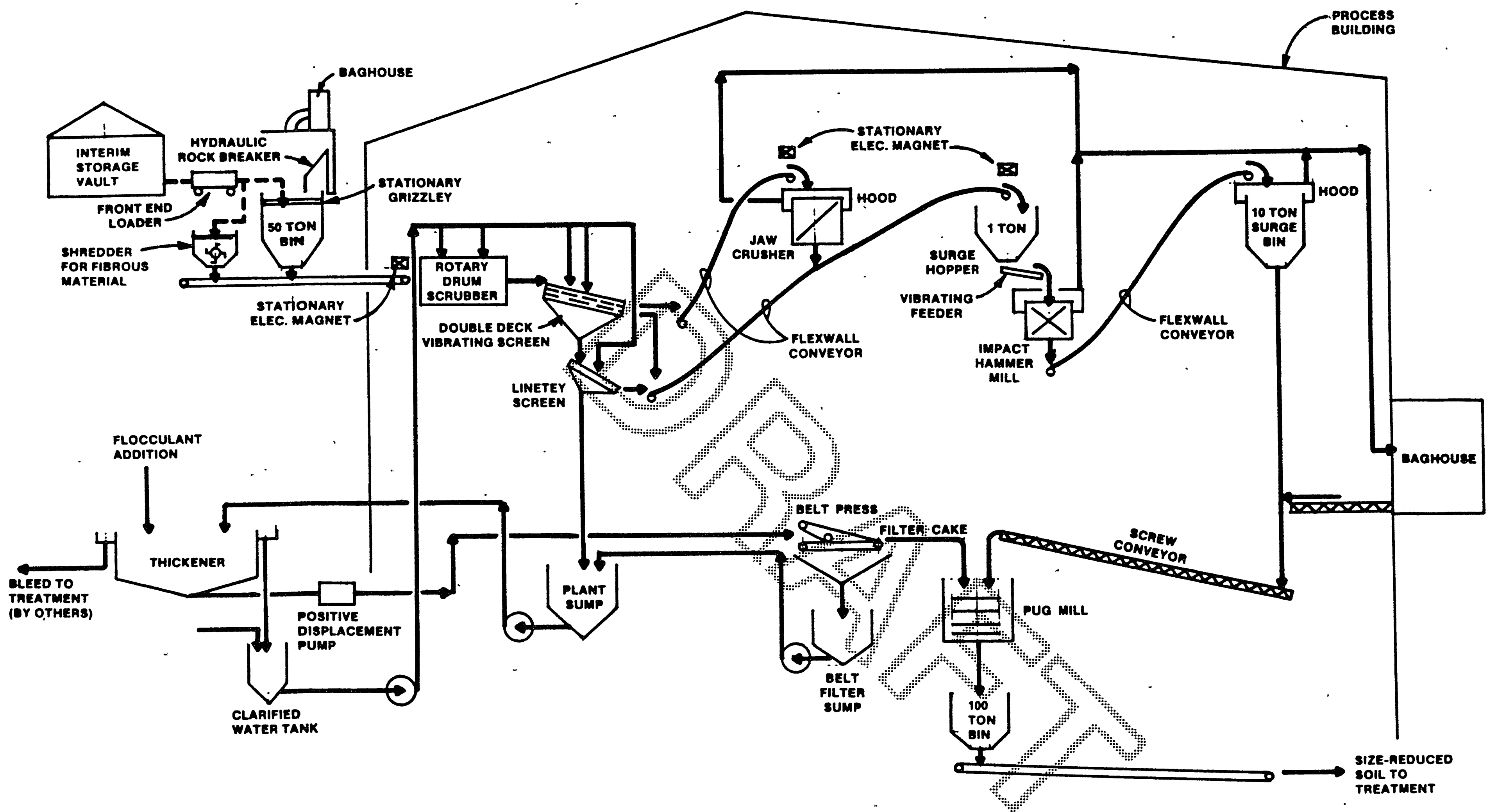


FIGURE 5-6
SIZE REDUCTION CONCEPTUAL FLOW DIAGRAM

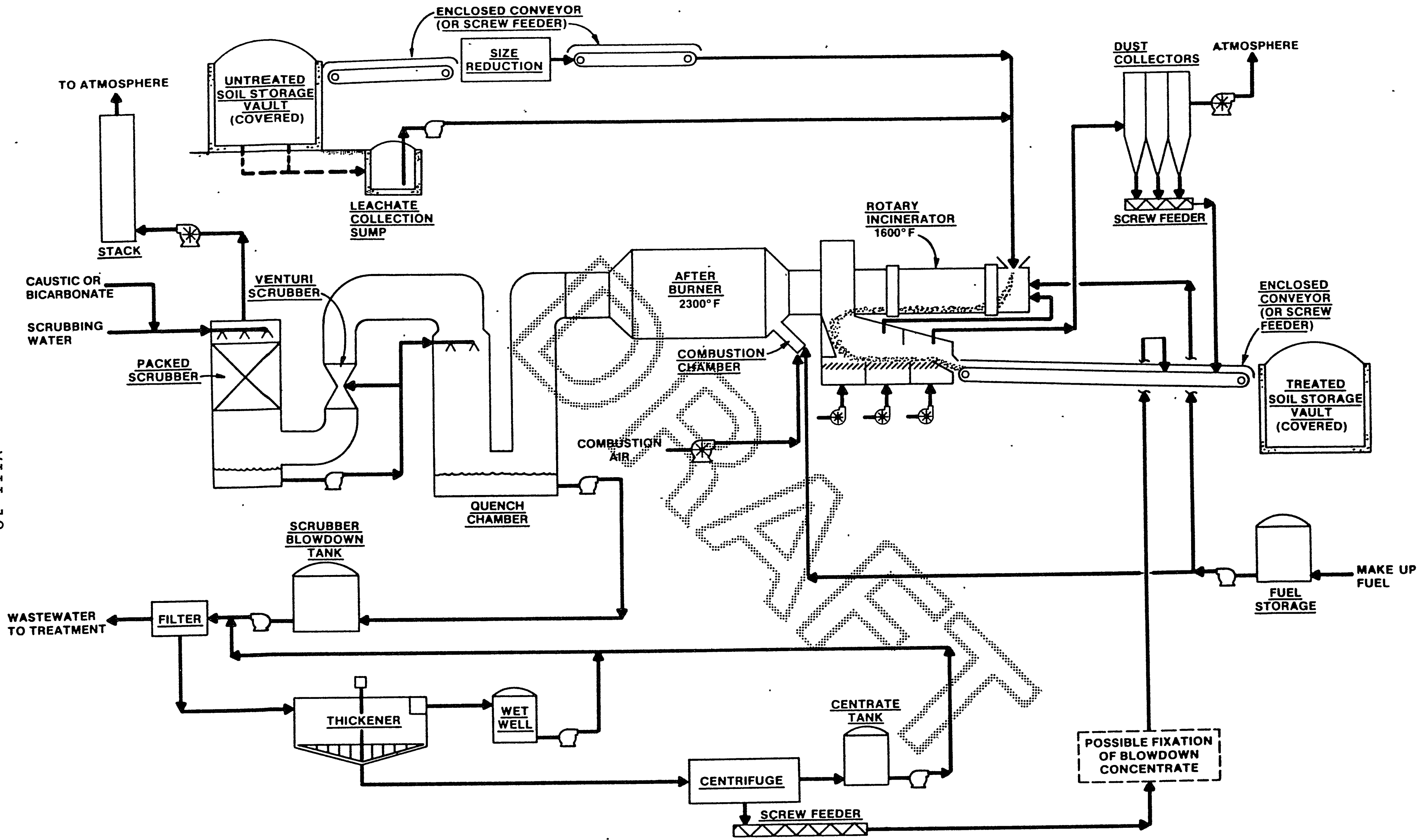


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FIGURE 5-7
INCINERATION
CONCEPTUAL FLOW DIAGRAM

PRELIMINARY

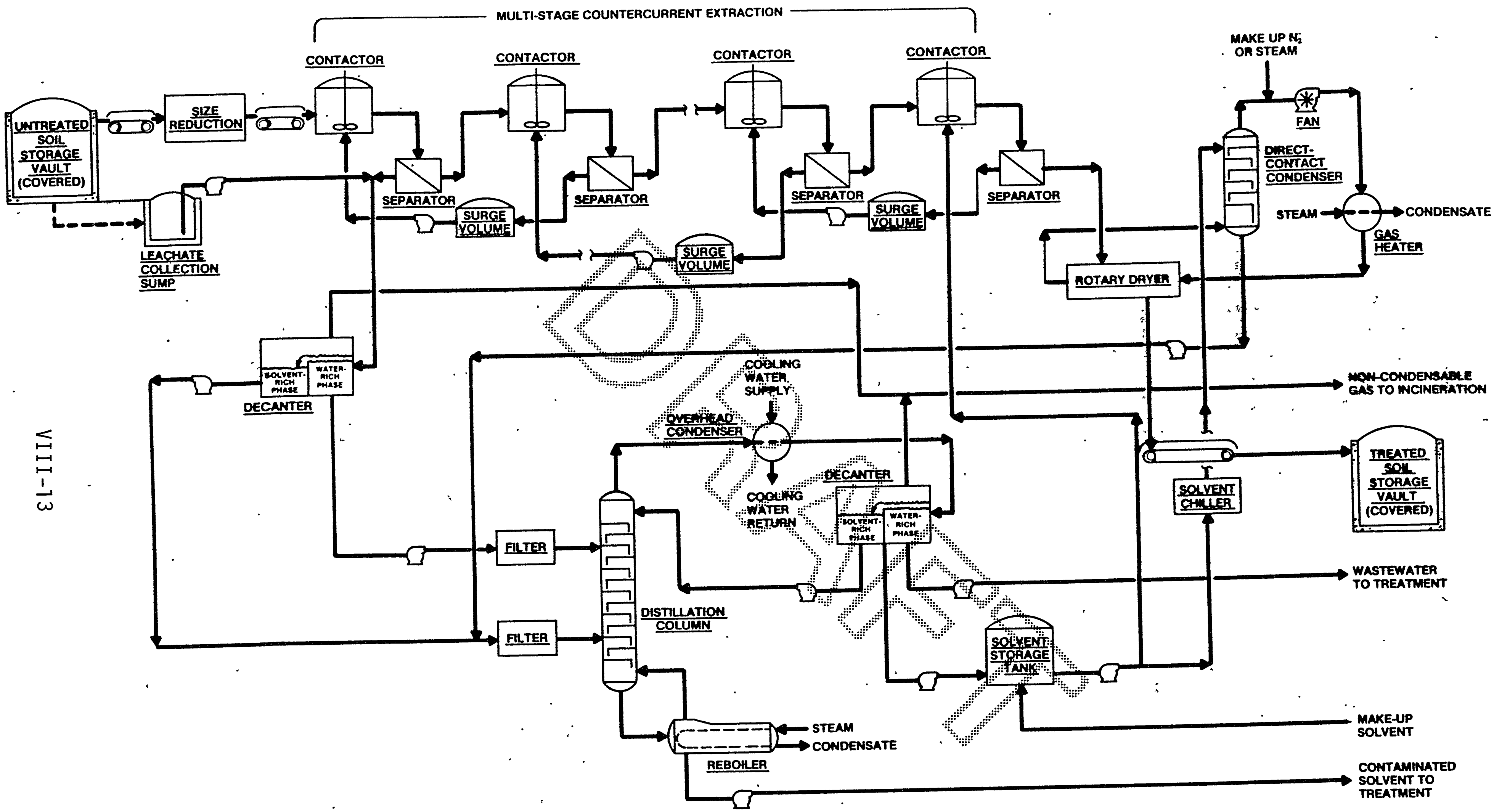


FIGURE 5-8
SOLVENT EXTRACTION CONCEPTUAL FLOW DIAGRAM

PRELIMINARY

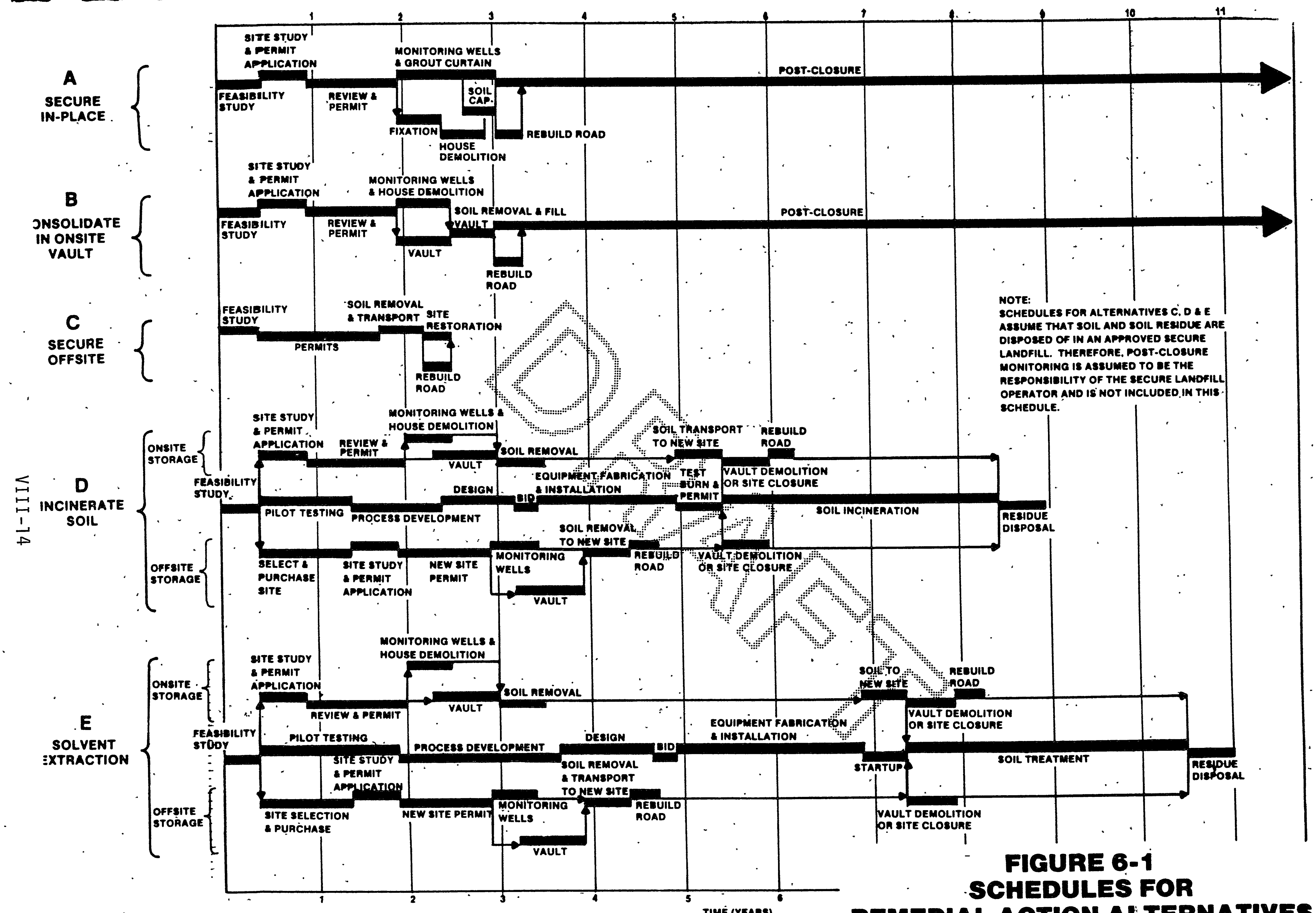
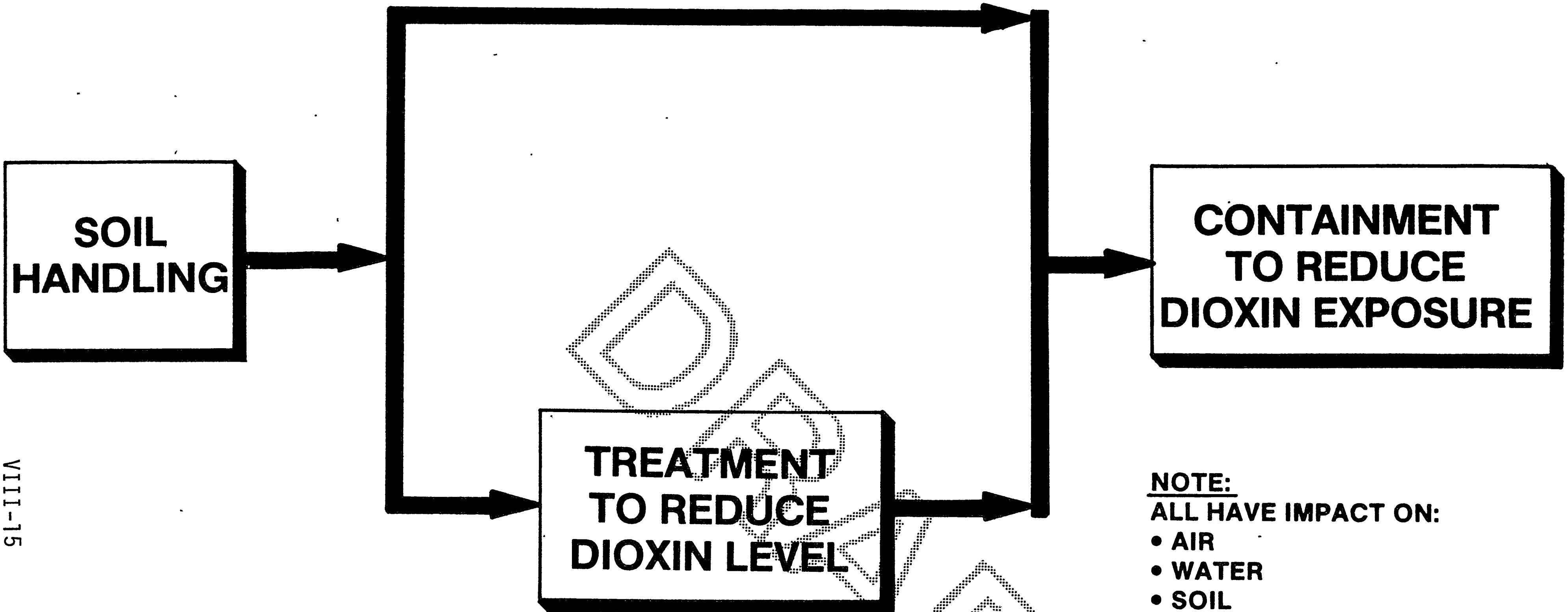


FIGURE 6-1
SCHEDULES FOR REMEDIAL ACTION ALTERNATIVES MINKER/STOUT



NOTE:
ALL HAVE IMPACT ON:
- AIR
- WATER
- SOIL
- PLANT & WILDLIFE
- WORKERS
- PUBLIC
- COMMUNITY

FIGURE 8-1
REMEDIAL ACTION CONCEPTUAL APPROACHES
MINKER/STOUT

TABLE 8-1
TCDD EXPOSURE HAZARD SOURCES PRESENT IN REMEDIAL ACTION ALTERNATIVES

TCDD EXPOSURE HAZARD SOURCES	REMEDIAL ACTION ALTERNATIVES					
	A	B	C	D	E	F
AIR ROUTE:						
• DUST GENERATION:						
- Onsite Soil Handling	?	•	•	•	•	•
- House Demolition	•	•		?	?	?
- Rock Drilling	•	•	•	•	•	•
- Highway Transport			•	?	?	?
- Soil Size Reduction Processing				•	•	?
- Residue Handling				•	•	•
• TREATMENT EMISSIONS:						
- Incinerator Emissions				•	•	?
- Solvent Processing Emissions					•	?
- Venting During Upset				•	•	?
SURFACE WATER/GROUNDWATER ROUTE						
• WATER CONTACTING CONTAMINATED SOIL:						
- Runoff From Soil Handling Operations	•	•	•	•	•	•
- Leachate From Containment	•	•	•	•	•	•
- Soil Size Reduction Processing Wastewaters				•	•	?
• WATER CONTACTING PROCESSED SOIL OR RESIDUE FROM TREATMENT						
- Solvent Processing Wastewaters					•	?
- Wastewaters From Incineration				•	•	?
- Runoff From Residue Handling Operations				•	•	?
- Leachate From Containment of Processed Soil Residue				•	•	?
- Emergency Spill				•	•	?
SOIL ROUTE						
• RELEASE OF CONTAMINATED SOIL						
- Onsite Soil Handling	?	•	•	•	•	?
- Soil Size Reduction Processing				•	•	?
- Highway Transport			•	?	?	?
• RELEASE OF PROCESSED SOIL OR RESIDUE FROM TREATMENT						
- Contaminated Soil From Solvent Treatment					•	?
- Contaminated Soil or Residue From Incineration Treatment				•	•	?

TABLE 8-2
RELATIVE RANKING OF ADVERSE ENVIRONMENTAL IMPACTS OF REMEDIAL ACTION ALTERNATIVES

ADVERSE ENVIRONMENTAL IMPACTS	REMEDIAL ACTION ALTERNATIVES					
	A	B	C	D	E	F
PLANT AND WILDLIFE						
1. TCDD Exposure						
- Air Route	low	low	low	high	med	
- Water Route	low	low	low	med	high	
- Soil Route	low	low	low	med	high	
2. Habitat Destruction	med	med	low	high	high	
WORKERS						
1. TCDD Exposure						
- Air Route	low	low	low	med	med	
- Water Route	low	low	low	med	high	
- Soil Route	med	med	med	med	high	
PUBLIC						
1. TCDD Exposure						
- Air Route	low	low	low	high	med	
- Water Route	low	low	low	med	high	
- Soil Route	low	low	low	med	high	
2. Noise	high	med	med	high	high	
COMMUNITY RESOURCES						
1. Land Area Committed	med	med	low	high	high	
2. Land Use Change	med	med	low	high	high	
3. Energy Consumption	low	low	low	high	high	
4. Topsoil	med	med	med	med	med	
5. Superfund Funding	med	low	low	med	high	
6. Road Deterioration	high	med	med	high	high	

COST ITEM	REMEDIAL ALTERNATIVES					
SOIL HANDLING/ SOIL REMOVAL						
MOBILIZATION/DEMOBILIZATION						
SOIL REMOVAL						
DECONTAMINATION						
PERIMETER FENCE						
SITE TESTING						
REROUTE RUNOFF						
REBUILD ROAD						
MISC.						
SUBTOTAL						
CONTINGENCY, ENGINEERING, BONDING, INSURANCE, INFLATION ALLOWANCE, ADMINISTRATION						
TOTAL						
TRANSPORTATION						
PERMITTING						
LOADING AND SITE CREW						
HAULING						
DECONTAMINATION						
SUBTOTAL						
CONTINGENCY, ETC.						
TOTAL						
STORAGE VAULT						
SITEWORK						
OFFSITE: PURCHASE LAND						
GEOHYDROLOGICAL STUDY						
SITE PERMITTING						
CONSTRUCT VAULT						
MONITORING WELLS						
LOAD/UNLOAD VAULT						
DECONTAMINATION AND REMOVE VAULT						
SUBTOTAL						
CONTINGENCY, ETC.						
ONSITE DECONTAMINATION						
ONSITE HOUSE DEMOLITION						
CONTINGENCY, ETC.						
TOTAL *						
* DOES NOT INCLUDE PURCHASE OF LAND FOR BUFFER ZONE						
SIZE REDUCTION						
SITEWORK						
FEED CONVEYORS/HOPPERS						
DRUM SCRUBBER						
SCREENS/CRUSHERS/BALL MILL						
DEWATERING EQUIPMENT						
PRODUCT CONVEYORS/HOPPERS						
BUILDING AND ENCLOSURES						
SUBTOTAL						
CONTINGENCY, ETC.						
TOTAL						

ONSITE CONSTRUCTION						
INTERCONNECTING PIPING						
INTERCONNECTING ELECTRICAL						
PROCESS INSTRUMENTATION						
SUBTOTAL						
CONTINGENCY, ETC.						
TOTAL						
OPERATING LABOR						
FUEL						
ELECTRICITY						
MAINTENANCE						
PILOT TESTING AND TEST BURN						
TOTAL						
SOIL RESIDUE VAULT						
TRANSPORT RESIDUE						
DISPOSAL OF RESIDUE						
TOTAL						
SOLVENT EXTRACTION						
SITEWORK						
CONTACTORS/MIX TANKS						
DECANT TANKS						
SEPARATORS						
DISTILLATION/CONCENTRATION						
SOIL DRYERS						
BUILDING/TANKAGE						
DEGRADATION						
TRANSPORT SOLVENT						
INCINERATE SOLVENT						
SCRUBBER WATER TREATMENT						
SUBTOTAL						
CONTINGENCY, ETC.						
TOTAL						
OPERATING LABOR						
SOLVENT						
ELECTRICITY						
MAINTENANCE						
PILOT TEST AND STARTUP TEST						
TOTAL						
SOIL RESIDUE VAULT						
TRANSPORT RESIDUE						
DISPOSAL OF RESIDUE						
TOTAL						

COMPARISON OF COSTS INCLUDED IN REMEDIAL ALTERNATIVES

PRELIMINARY

4-12-83